

THE BRITISH
JOURNAL OF SURGERY

THE BRITISH JOURNAL OF SURGERY

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VOLUME ~~XI~~

July 1923 to April 1924 Numbers 41 to 44

BRISTOL JOHN WRIGHT AND SONS LTD
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UNITED STATES OF AMERICA WILLIAM WOOD AND CO, NEW YORK *Sole Agent*

PRINTED IN ENGLAND
BY JOHN WRIGHT AND SONS LTD, BRISTOL

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VOL XI

JULY, 1923

No 41

EPONYMS

By SIR D'ARCY POWER, KBE, LONDON

IX POTT'S DISEASE OF THE SPINE

PERCIVALL POTT published two pamphlets upon that condition of the spinal column which is now called Pott's disease. The first is a small octavo which was printed for J Johnson, No 72 St Paul's Churchyard, in 1779. It is entitled "*Remarks on that kind of Palsy of the Lower Limbs which is frequently found to accompany a Curvature of the Spine and is supposed to be caused by it*", price one shilling and sixpence. It was translated into French by Dr A B Beerenbroek soon after its appearance, and was published at Brussels. The second pamphlet by the same publisher was issued three years later in 1782 under the title "*Further Remarks on the useless state of the Lower Limbs in consequence of a Curvature of the Spine being a Supplement to a former treatise on that subject*". This pamphlet is illustrated by six engravings showing the changes which take place in the vertebrae as a result of the disease.

The first pamphlet may be said to deal with the clinical features of the disease, the second with the morbid anatomy. Pott dedicates his work to Dr John Lewis Petit, one of the physicians to St Bartholomew's Hospital, as a small mark of the great esteem and regard of the author. He then goes on to say "The disease of which I mean to speak, is generally called a palsy, as it consists in a total or partial abolition of the power of using and sometimes of even moving the lower limbs, in consequence, as is generally supposed of a curvature of some part of the spine. To this distemper both sexes, and all ages, are equally liable and until the curvature of the spine has been discovered, it generally passes for a nervous complaint. I have in compliance with custom called the disease a palsy

yet there are some essential circumstances in which this affection differs from a common nervous palsy. The legs and thighs are rendered unfit for all the purposes of locomotion and do also lose much of their sensibility but they have neither the flabby feel which a truly paralytick limb has, nor have they that seeming looseness at the joints, nor that total incapacity of resistance, which allows the latter to be twisted in almost all

directions, on the contrary the joints have frequently a considerable degree of stiffness, particularly the ancles, by which stiffness the feet of children are generally pointed downward, and they are prevented from setting them flat upon the ground

"The curvature of the spine, which is supposed to be the cause of this complaint, varies in situation, extent and degree, being either in the neck or back, and sometimes (though very seldom) in the upper part of the loins, sometimes comprehending two vertebrae only, sometimes three, or more but whatever may be the number of vertebrae concerned or whatever may be the degree or extent of the curvature, the lower limbs only feel the effect—at least I have never once seen the arms affected by it. While the curvature of the spine remains undiscovered or unattended to the case is generally supposed to be nervous, and medicines so called are most frequently prescribed, together with warm liniments embrocations, and blisters to the parts affected, and when the true cause is known, recourse is always had to steel stays, the swing, the screw chair, and other pieces of machinery in order to restore the spine to its true and natural figure, but all, as far as I have observed, to no real or permanent good purpose, the patient becomes unhealthy, and languishing for some time under a variety of complaints dies in an exhausted, emaciated state."

Pott states that his attention was directed to "this distemper by its occurring in the person of a very promising youth of fourteen years old, with whose family I was nearly connected" and that while the subject was in his mind he happened to be at Worcester "and in a conversation with the late Dr. Cameron of that place I mentioned to him my opinion that previous both to the paralytic state of the legs and to the alteration of the figure of the backbone, there is a predisposing cause of both consisting in a distempered state of the ligaments and bones, where the curve soon after makes its appearance. The Doctor concurred with me, and said that he remembered some years ago to have noted a passage in Hippocrates in which he speaks of a paralysis of the lower limbs being cured by an abscess in the back or loins. He had acted on this hint and had endeavoured to imitate this act of nature by exciting a discharge near the part and that it had proved very advantageous. A similar good result had been obtained by Mr. Jeffrys, a surgeon of eminence at Worcester. I determined to try the method, and the first case that offered was in an infant whose curvature was in the middle of the neck and who had lost the use of its legs for two or three months. I made an issue by incision on one side of the projection, and gave strict charge to the mother to take care that the pea was kept in, the woman, who had no faith in the remedy did not take the proper care, and consequently the discharge was not equal to what it should, and might have been, but notwithstanding this neglect at the end of about three weeks or a month the child was manifestly better and began to make use of its legs, it was then seized with the small-pox and died. My next patient was a tall thin man about thirty-five years old who thought that he had hurt himself by lifting a heavy weight, his legs and thighs were cold and what he called nummy, but not absolutely useless. I made a seton on each side of the curve, and having given his wife directions how to dress them I called on him once in three or four days. At the end

of six weeks he had recovered the due degree of sensation in his limbs and could rise from his bed and from his chair without assistance. The setons had now, from not having been properly managed worn their way out, and I would have converted each of them into an issue, but as neither the patient nor his wife had ever believed that the discharge had had any share in his amendment but on the contrary that he would have been better without it he would not submit to what I proposed and I left him. At the distance of about three weeks from the time of my leaving him I met him in the street walking very stoutly with a common cane, of which he made little or no use. I asked him what he had done, he told me that the sores had continued to discharge till within a few days, but that he had drank a great deal of comfrey-root tea with isinglas, and he supposed that had cured him. I believe that the cure of this man will by all who know anything of medicine, be thought to be so unlikely to have been affected by the comfrey and isinglas that my inference in favour of the seton will not be thought unreasonable, and that my determination to prosecute the method, from what I had seen and heard, was well founded.

In spite of these discouragements Pott continued the treatment, and "within these last six or eight months several cases of curved spine have been received into St Bartholomew's Hospital where they have been seen by great numbers of the profession. The novelty of the treatment and the success which has hitherto constantly attended it has necessarily engaged the attention of many and occasioned some observations on the subject. Although I have called this an early publication, yet I have waited a sufficient length of time and have treated a sufficient number of subjects to be clear in the truth of what I have asserted as far as such time and such individuals go. That the patients whom I have attended in the early part of the distemper of whatever age, have all got well, that is have not only regained the use of their legs but have become healthy, and fit for any exercise or labour, as numbers can testify who have seen them daily. Most of them have become much straighter, some quite straight, and all of them perfectly free from all kind of inconvenience arising from the curve. That as far as my experience goes I have not the least doubt, that if the means proposed, be made use of before the bones become really carious and rotten, that they will always be successful. When indeed a truly rotten state of the bones takes place no good is to be expected from this or from anything else, but it should be observed at the same time, that this never happens but when the distemper is of very old date, and that when this is the case, the whole machine is so disordered, and the patient so truly and so generally distempered, that there can be no reasonable expectation of success from any thing."

There is no doubt that Pott was perfectly honest in his belief, but the whole train of argument shows that he was relying entirely upon empiricism, and that, having a firm belief in the efficacy of counter-irritation he made no effort to seek for any other cause for the improvement. He did not take into consideration the curative effects of rest whilst the patients were in hospital nor did he make any careful post-mortem examinations of the diseased tissues, for he contented himself with a mere examination of the vertebral column and with maceration of the bones. In excuse it may be urged that

John Hunter was one of his pupils, and consequently surgical morbid anatomy was not yet existent

Pott begins his "Faither Remarks" with the following words "It is now near three years since I first troubled the public with my observations on the disease which makes the subject of the following tract" He excuses his former paper on the ground of the importance of the subject the perfect safety of the experiment, and the desire to obtain evidence of the utility of his method of treatment from other surgeons "My wishes and my expectations have been fulfilled I have received such manifold and repeated testimony of the success of the proposed method, from so large a number of the most eminent practitioners, not only in this town and kingdom but in many other parts of Europe, that these, added to my own experience, have completely satisfied me, and enabled me to say, that in proper cases, and under proper treatment, I have no doubt of its being universal In all the time which has passed since the first publication, I have sought and embraced every opportunity of obtaining information, both from the living and from the dead" He then recapitulates what he had stated in the previous communication and gives an excellent picture of the early symptoms "The account most frequently given is, that for some time previous to the incapacity the child had been observed to be languid, listless, and very soon tired, that he was unwilling to move much or briskly, that he had been observed frequently to trip and stumble, although no impediment lay in his way, that when he moved hastily or unguardedly, his legs would cross each other involuntarily, by which he was often and suddenly thrown down, that if he endeavoured to stand still, and upright, unsupported by another person, his knees would totter and bend under him, that he could not with any degree of precision or certainty, steadily direct either of his feet to any particular point, but that in attempting so to do, they would be suddenly and involuntarily brought across each other, that soon after this, he complained of frequent pains and twitchings in his thighs, particularly when in bed, and of an uneasy sensation at the pit of his stomach, that when he sat on a chair, or a stool, his legs were almost always found across each other, and drawn up under the seat, and that in a little time after these particulars had been observed, he totally lost the power of walking"

The picture seems very simple, and it could now have been drawn by any observant medical student, but it had never been painted before, and it has now become a part of surgery He continues "In infants the curve is seldom noticed till it has got to such a size and state, as to demand attention from the deformity, previous to this, all the marks of distemper which appear in the child, pass for the effects of general weakness, and are treated as such, differently by different people, and under different circumstances, but never with any permanent good effect, some of the adventitious symptoms, if I may so call them, are in some degree relieved but the principal remain in full force or what is much more frequent go on increasing In an adult it passes for rheumatism, or gravel, or a sprain, and the defect in the limbs is the first thing that occasions an enquiry into the state of the back bone The true cause of the disease is a morbid state of the spine, and of some of the parts connected with it, which distempered state of parts will, upon careful



A View of some of the Vertebrae in a case of Curved Spine which had been Cured by the Caustic & which were taken from the body of the Patient who died of another Distemper at some distance of Time after. In this may be seen the State of the Vertebra which had been Crushed and of the Consequent Anchylosis or Union.

Oct 20 1752. Published at the Request of the Author

R. Laurie fecit

enquiry, be always found to have preceded the deformity some length of time, in infants this is the sole cause and external violence has nothing to do with it. In the adult, I will not assert that external mischief is always and totally out of the question but I will venture to affirm what is equal, as far as regards the true nature of the case, which is that although accident and violence may in some few instances be allowed to have contributed to its more immediate appearance, yet the part in which it shows itself, must have been previously in a morbid state, and thereby predisposed for the production of it.

"The primary and sole cause of all the mischief, is a distempered state of the parts composing or in immediate connection with the spine, tending to and most frequently ending in a caries of the body or bodies, of one or more of the vertebrae, from this proceed all the ills whether general, or local, apparent, or concealed, this causes the ill health of the patient, and in time, the curvature. The helpless state of the limbs is only one consequence of several proceeding from the same cause, but though this effect is a very frequent one, and always affects the limbs in nearly the same manner yet the disease not having its origin in them, no application made to them only can ever be of any possible use. The same failure of success attends the use of the different pieces of machinery, and for reasons which are equally obvious.

"They are all, from the most simple to the most complex, but particularly the swing and the screw, calculated to obviate and remove what does not exist. They are founded upon the supposition of an actual *dislocation* which never is the case, and therefore they always have been and ever must be unsuccessful."

Pott then reiterates his belief in the value of counter-irritation in the treatment of these cases saying "It is a matter of very little importance towards the cure, by what means the discharge be procured, provided it be large, that it come from a sufficient depth, and that it be continued for a sufficient length of time. I have tried the different means of setons, issues by incision, and issues by caustic and have found the last in general preferable being least painful, most cleanly, most easily manageable, and capable of being longest continued. The caustics should be applied on each side of the curvature, in such a manner as to leave the portion of skin covering the spinal processes of the protruding bones, entire and unhurt and so large, that the sores upon the separation of the eschars, may easily hold each three or four peas in the case of the smallest curvature, but in large curves, at least as many more. These issues should not only be kept open, but the discharge from them should be maintained by means of orange peas, cantharides in fine powder, aerugo aeris, or any such application as may best serve the intended purpose which should be that of a large and long-continued drain."

Having considered the clinical and curative aspects of the disease Pott concludes these remarkable contributions to surgery by some remarks upon the morbid anatomy of the condition, saying "This morbid affection shews itself in a variety of forms, but although its appearances be various, yet they are always such as determine the true nature of the distemper. Sometimes it appears in a thickened state of the ligaments, connecting the vertebrae together, without any apparent affection of the bones. Sometimes in the

form of a distempered state of the intervertebral substances, called cartilages. Sometimes in that of diseased glands, either in a merely indurated and enlarged state, or what is more frequent in that of a partial suppuration. Sometimes it is found in the form of bags or cysts, containing a quantity of stuff of a unequal consistence, partly purulent, partly sanious, and partly a curd-like kind of substance, and not infrequently entirely of the last. Sometimes under these bags, or cysts, even while they remain whole the subjacent bones are found to be distempered, that is deprived of periosteum, and tending to become carious. Sometimes these collections erode the containing membranes, and make their way downward by the side of the psoas muscle towards the groin, or by the side of the pelvis behind the great trochanter or in some cases to the outside of the upper part of the thigh. The disease which produces these effects on the spine, and the parts in its vicinity, is what is in general called the sciophula, that is, that same kind of indisposition as occasions the thick upper lip, the tedious obstinate ophthalmia, the indurated glands under the chin, and in the neck, the obstructed mesentery, the hard dry cough, the glairy swellings of the wrist and ancles, the thickened ligaments of the joints, the enlargement and caries of the bones &c, &c, &c.

Both essays are well worth reading, as well for their excellence as for their defects. They show Pott to have been better in differential diagnosis and treatment than in his knowledge of morbid anatomy. But considering the difficulty of making post-mortem examinations in the "dead house beneath the Cutting Ward at St Bartholomew's Hospital" the specimens he succeeded in obtaining were satisfactory. It is clear that the results of the treatment he recommended were due to the enforced rest, but the doctrine of physiological rest was not enunciated for nearly one hundred years after his death. He carried it out empirically, and in so doing displaced for ever the ambulatory system and the use of the complicated mechanical apparatus which had been a torture to many unhappy patients.

The illustration is reproduced from the rare original pamphlet and shows the stains or foxing which are not uncommon in paper of the period.

THE FLOW OF LYMPH FROM THE ILEOCÆCAL ANGLE, AND ITS POSSIBLE BEARING ON THE CAUSE OF DUODENAL AND GASTRIC ULCER.

BY L R BRAITHWAITE, LEEDS

*(Being the Arnis and Gale Lecture delivered at the Royal College of Surgeons of
England on February 21, 1923)*

GENERAL OBSERVATIONS

EVIDENCE of inflammatory change in the right iliac fossa is common enough to be familiar to every surgeon. There is no part of the intestinal canal where such remarkable adhesions, bands and kinks arise. The gall-bladder frequently presents striking adhesions, and to a much less extent the splenic flexure of the colon (Payr's disease). According to Lane there are non-inflammatory reasons for the ileal kink and for Jackson's cæcal membrane, but it is frequently obvious that exactly similar conditions appear as a result of some pathological process usually arising in the appendix. It is common enough to see the various adhesions, bands, and kinks actually in the stage as they are laid down by deposits of plastic lymph, adhesions which can easily be separated by the finger. It is not possible to escape from a belief that for the most part these conditions are inflammatory. Certainly disease of the appendix is the almost universal cause though conditions arising in the cæcum and lowest part of the small intestine probably sometimes play a part (*Fig 1*).



FIG 1—Showing the common types of adhesions found in the pericæcal area

Subacute inflammation of the appendix is accompanied by a widespread peritonitis more marked in its violence and extent than that due to inflammation of the rest of the alimentary canal. In cases where no history of an acute attack of appendicitis can be obtained, bands of omentum

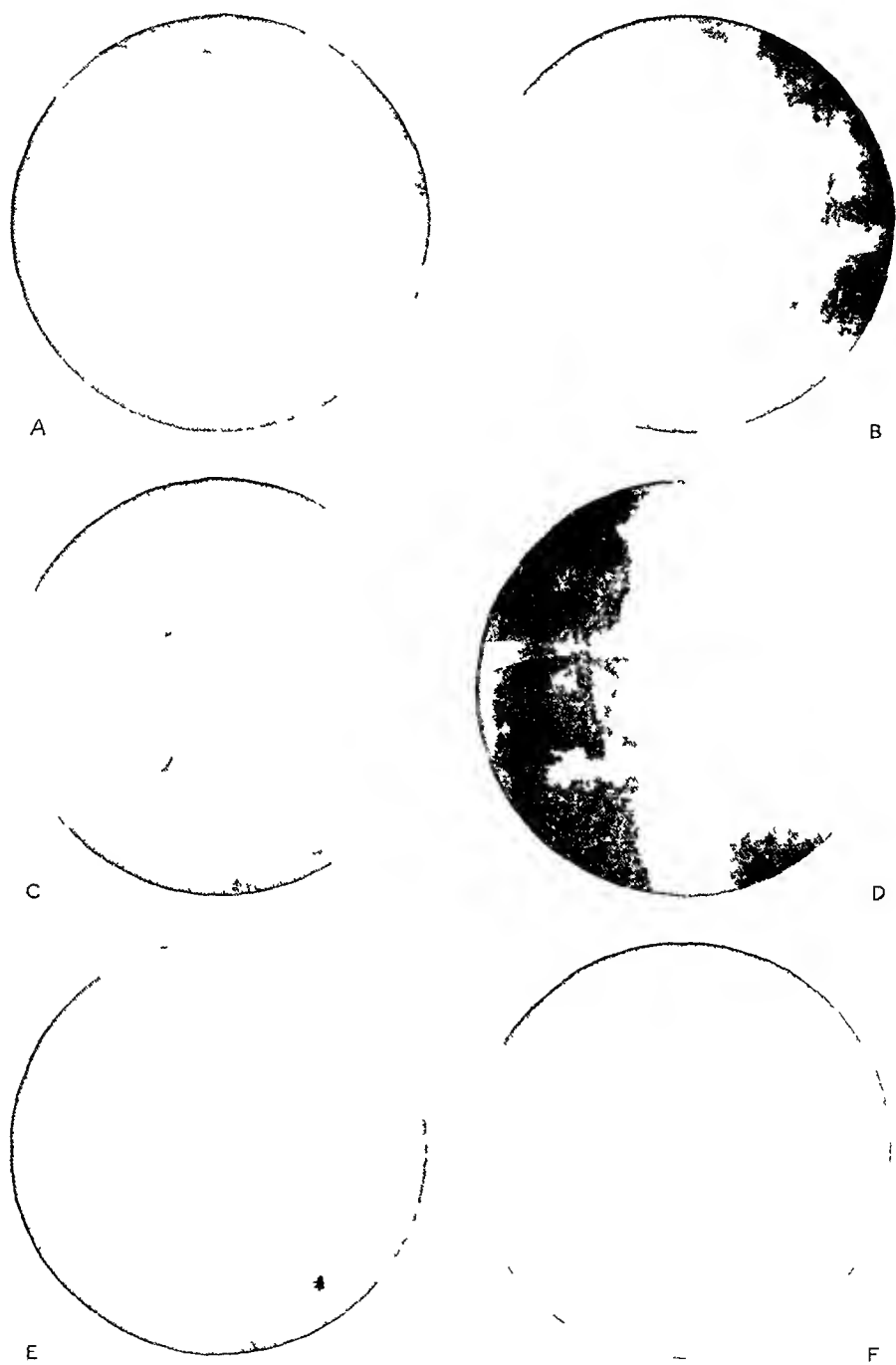


FIG. 2—Radiograms of calcified ileocecal glands (*all except B are shown reversed*)

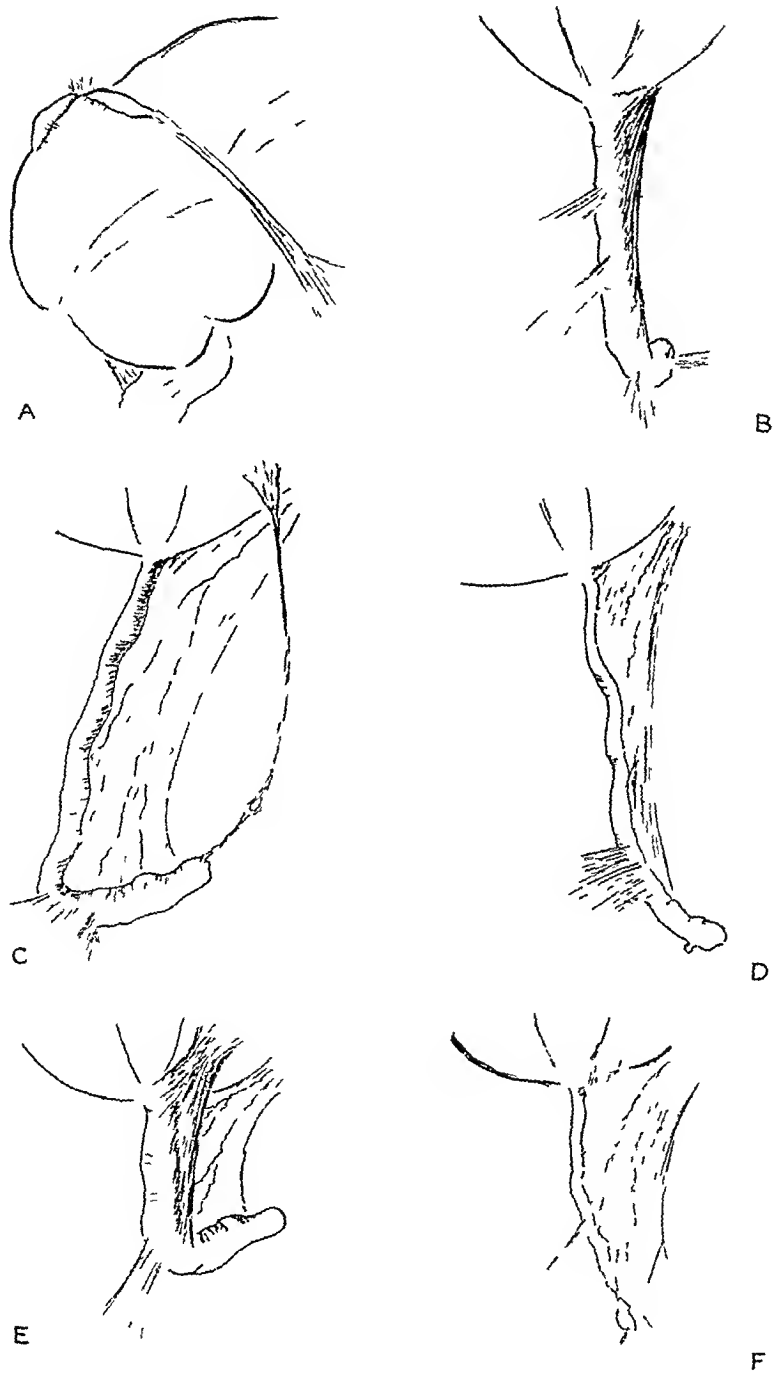


FIG. 3.—Selected drawings of the appendix as seen in cases of duodenal ulcer

crossing the ascending colon and kinking of the ileum, one, two, or three inches from the ileocecal junction, are frequently found, together with a badly diseased appendix—it might fairly be suggested therefore that there is some faculty of actual penetration possessed by the infecting agent, or some tenacity or other weakness in the walls of the appendix or the bowel contiguous to it not present in other parts of the alimentary canal.

That infection arising in the ileocecal area is common enough is also shown by the frequency with which both tuberculous and non-tuberculous enlargement of the ileocecal glands is found (*Fig 2*). Does this infection give rise to any disturbances in other parts of the abdomen? Under the conditions usually seen, infection is clearly most likely to spread by lymphatic channels.

Moynihan, Mayo, Murphy, MacCarthy, Ochsner, Deaver, McGrath, Pateison, Wilkie, and others have considered certain kinds of indigestion, duodenal and gastric ulcer, and gall-stones as possibly due in some way to the changes seen in the region of the appendix. In an epoch-making article, "Appendix Dyspepsia", Moynihan¹ describes cases of dyspepsia associated with certain obvious changes in the stomach. Pateison,² in an article written at the same time and published slightly later, writes on similar lines.

In Moynihan's words, in these cases the stomach presents the following signs: "There is no thickening, no whiteness, no puckering, no adhesions. The stomach looks in every particular quite normal. But if it be allowed to lie quietly for inspection (and it is better to watch it while the abdominal wall is raised up before the organ is handled), a most interesting condition is displayed. The stomach in its pyloric half is seen to be in vigorous and excited action. At the point where the vertical and horizontal parts of the stomach merge, a contraction starts and spreads towards the pylorus, and at last involves all the pyloric antrum. The stomach becomes thick, contracted and pale, its muscle is evidently in a state of strained and vigorous action and the channel through it is almost obliterated. On the cardiac side of this area of spasm the stomach is quiet, a little distended even and shows no movement."

In his second edition of *Duodenal Ulcer*³ will be found a page of drawings made by the writer, illustrating the conditions in the region of the appendix, some of which are here reproduced (*Fig 3*).

Since 1908, those who have been privileged to work with Moynihan have given the closest attention to this condition through over 1000 abdominal operations, and have come to recognize three gastric stigmata which enable them to diagnose a diseased appendix almost with certainty whilst it is still out of sight. The three stigmata are (1) Pyloric spasm, (2) Pyloric congestion, (3) Enlargement of glands on the greater curvature of the stomach towards the pylorus, i.e., along the course of the right gastro-epiploic vessels.

1 *Pyloric Spasm*—Moynihan's description has already been repeated, it still vividly describes the condition (*see Fig 4*).

2 *Pyloric Congestion* is a term which allows of wide limits by it is indicated a blushing of this part of the stomach which is not normally present—it can only be seen in the intervals between the spasms, and because the surface vascularity of the normal stomach is greatest towards the pylorus,

it is only as a result of constant practice in abdominal surgery that one feels competent to appreciate it

3 *Enlargement of the Glands*—This is in another category it is easily seen if looked for, but is frequently obscured by fat. The glands lie between the

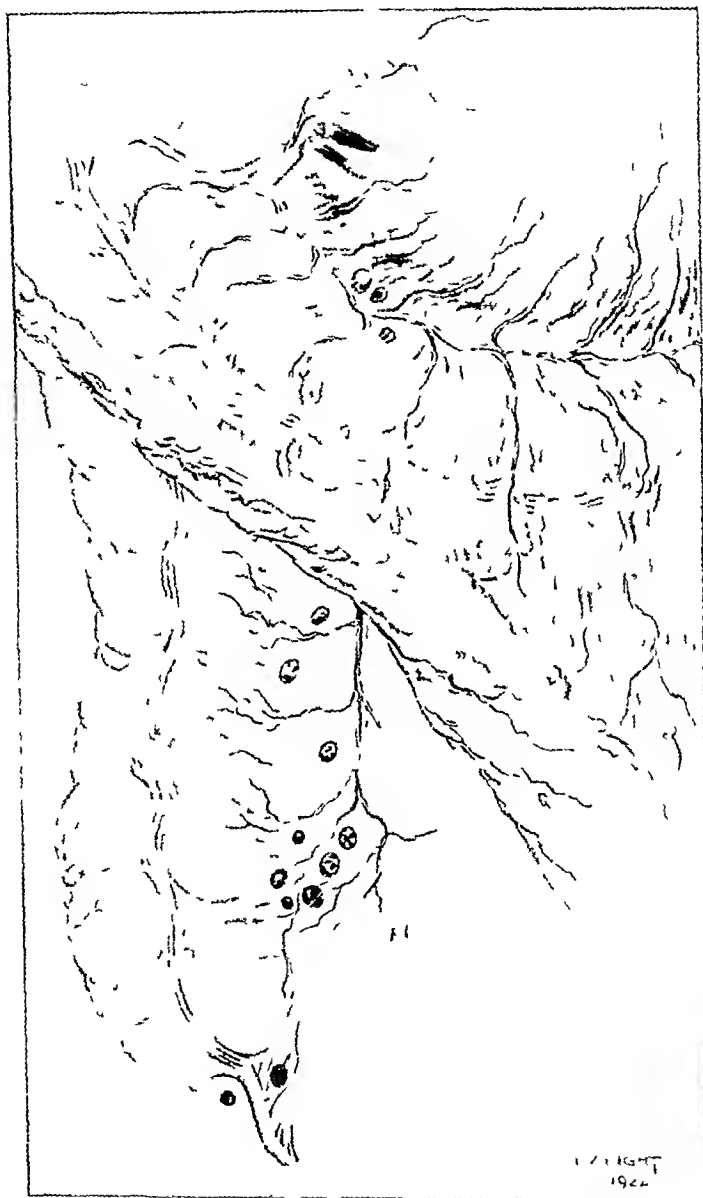


FIG. 4—Showing pyloric congestion and spasm, also the distribution of pigment in the case of 'pigmented appendix.'

layers of the great omentum. They are rarely close to the pylorus—more often two to three inches away. As a rule they are in two groups: the upper group consists of one or two glands lying above or on the right gastro-epiploic vessels; the lower and more numerous group always lies below the

vessels. It is a point of some importance that in these cases the lower group only is enlarged, as a rule. The glands are always red, fleshy, and freely movable.

In 1914 the writer came across a case which is remarkable in itself and of interest in that it led him to commence investigations into the causes of the enlargement of this group of glands. A lady, 30 years of age, was sent in with a diagnosis of acute appendicitis. The usual signs and symptoms were present and immediate operation was performed. On opening the abdomen an astonishing sight presented itself. The appendix was slightly congested but otherwise apparently normal. The ileocaecal glands were jet-black, and a chain of jet-black glands could be traced up to the duodenum and the superior mesenteric vessels where they cross it. In addition two of the glands on the

greater curvature of the stomach, two inches from the pylorus, were black (*Fig. 4*). The appendix was removed, one gland from the ileocaecal angle, and one from the stomach group. The pathologist's report was as follows—

REPORT ON APPENDIX AND GLANDS

1 *Appendix*—There is no evidence of malignant disease. The proximal third of the appendix mucosa is deeply pigmented. This is not a very rare finding apparently. Microscopic examination shows masses of pigment inside phagocytic cells disseminated in the interglandular tissue and following

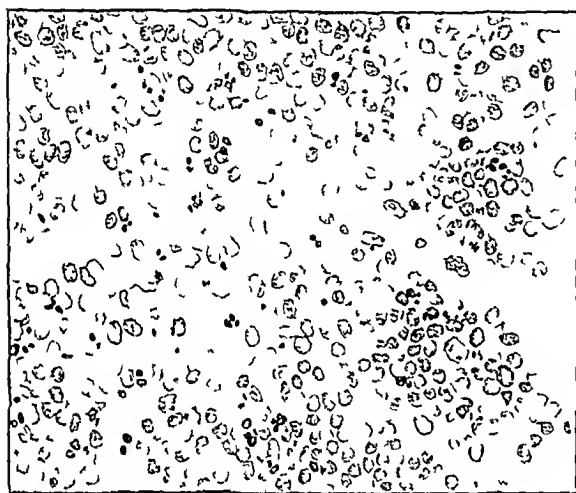


FIG. 5.—Microscopic appearance of lymph gland containing pigment derived from appendix.

the vascular channels. Some parts have collected at the periphery of the follicles of the lymphatic glands still lying within the endothelial cells.

2 *Glands*—The glands supplied are abnormal in their central sinuses, containing plasma and not lymph, as if this were a form of hemolymph gland. The reason for the pigmentary deposit is the appendiceal lumen. (Change in the fibres with absorption of the abnormal products?) (*Fig. 5*)

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This case certainly suggested that there must be some lymphatic path whereby the pigment could travel to the stomach. It also suggested that, if pigment could reach this area from the appendix, infection could do the same thing.

NORMAL FLOW OF LYMPH

The normal flow of lymph from the ileocaecal angle in a perfectly healthy individual, as gleaned from post-mortem injections—largely in the foetus—is clearly defined. Gathering tributaries from the appendix, the caecum, and the last six inches of the small intestine (in part only) the lymphatics pass

irregularly in a group of five or six vessels to the chain of glands which lies dotted along the line of the ileocolic artery. The main efferent trunks pass up in front of the third part of the duodenum reaching the group of glands massed round the superior mesenteric artery, and so the lumbar chain. If, now, it be true that from here the efferents pass wholly and directly to the lumbar group and so to the receptaculum chyli, then there can be no direct path of lymph from the ileocæcal angle either to the stomach or the duodenum. It was the object of this research, by experiments in both living and dead subjects, to find out (1) Whether aberrant paths existed, and (2) What effect disease of lymph vessels or glands would have on the lymph flow.

Experiments in Animals—For this purpose experimental work was commenced on cats. The various lymph-sheds of the abdomen were injected by means of a hand syringe with a very fine steel needle. All cats would appear, on abdominal section, to have masses of diseased mesenteric glands, most of these on microscopical examination prove to be quite healthy, some prove to be tuberculous. The diagnosis as between a hyperplasia of a lymph gland and an early condition of tuberculosis is not easy even with the microscope. It was found that there were vast differences between the living and the dead animals, both in the ease with which the injection could pass through lymphatic glands and vessels, and in the extent of area injected. The arrangement of the intestinal canal of a cat is primitive, the appendix is weakly represented by a rather marked cæcal tip which, however, contains large masses of lymphoid tissue.

After considerable practice to obtain a steady and even pressure—by no means an easy business—it was found to be possible, in living cats where the glands were not obviously diseased, to inject indigo-carmin from the tip of the cæcum into the whole lymph-shed up to the pancreas and over it into the glands which lie *above* it. Glands which lie in close contact with the upper and lower border of the pylorus were frequently injected from the cæcal wall. In the dead animal (many attempts were made very soon after the animal had been taken from the lethal chamber) this was never accomplished, the injection would reach the lower border of the pancreas, but no further.

An attempt was now made by implanting active tuberculous gland tissue from a human being into the submucous layer of the cæcal wall of a cat and into the wall of the small intestine near the ileocæcal valve, to produce in course of time a tuberculous manifestation in the pyloric glands. Eventually, starting with an animal whose glands appeared healthy and which were healthy on microscopic examination, a chain of tuberculous glands was set up in the ileocæcal angle leading to a tuberculous gland in the subpyloric line. A kitten taken early from its mother and fed for three months on sterile food was found to have healthy mesenteric glands, after being fed on tuberculous gland tissue from human necks together with other and *sterile* food, it developed tuberculosis of the mesenteric and subpyloric glands. These specimens together with the gland sections were shown at the meeting of the Association of Surgeons in May 1922.

Experiments in Man—It was argued that as indigo-carmin is so extensively used in human beings for the purpose of estimating the work done by the kidneys and is passed from a subcutaneous or intramuscular injection

through the organism without any ill effects, it could not inflict any injury if injected into the lymph system of the appendix or other abdominal organ for the purpose of estimating whether or not the same striking ease and speed of flow as was seen in the living cat would be seen in the living man. Advantage was taken of unusual opportunities for performing abdominal section in man, to attempt similar injections to those made in animals. For this purpose a more equable and a definitely-known pressure was achieved by the use of a mercury column raised by air-pressure from an ordinary bicycle pump (*Fig 6*). The finest steel needles were used, fixed into thick rubber tubing, and a pressure of from 6 to 8 mm of mercury was found to

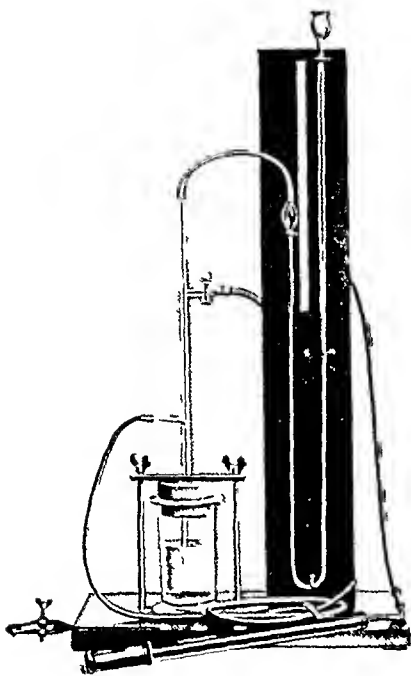


FIG 6—Mercury column raised by air pressure from a bicycle pump

be about sufficient, the pressure was increased where obstruction to the flow was observed. A careful sterilization of the storage chamber and the effluent tubes was effected, the latter being boiled before each injection. The solution used was similar to that injected into animals, i.e. 1-60 indigo carmine in distilled water. There were no ill effects either accompanying or following the injections, and as there was no mortality there are no specimens to show. Forty-eight injections were made in all.

What is already known of the difference in the ease of injection of healthy lymphatics under varying conditions?

Hunter was the first to point out that the difficulty of injecting lymphatics increased rapidly each hour after death, and also that injection was easier in young than in old subjects. Every worker has noted similar variations. Cuneo and Delamere,⁴ in their work on the lymphatics of the stomach remark that "the stomach used should be as fresh as possible", they regard injection of the subserous plexus as "almost impossible so soon as the peritoneal coat

has lost its normal consistency". They recommend that the stomachs of newly-born or very young subjects only be used. Moynihan,⁵ in connection with the lymphatic system of the stomach, says, "The greater part of the work of investigation has been carried out upon the bodies of fetuses or infants", and "It is stated by Polya and von Nussli that the number of the glands increases considerably in adult life either by the division of the original glands or by their fresh development from lymph vessels". Dobson and Jannesson⁶ carried out their work in fetuses or the newly-born.

Deposits of fat in the mesentery always prevented any injection being attempted because both glands and vessels were obscured.

One striking feature of an injection into the submucous coat of the stomach in the living subject as compared with a similar injection in the dead under a similar pressure is shown in the diagram (*Fig 7*) It will be noticed that the area coloured by the injection in the living stomach is one and a half times to twice that coloured in the dead organ in addition, the former injection takes place much more quickly than the latter

The first series of injections was made into the appendix It proved everything Jamieson and Dobson and others have written with regard to the flow of lymph from the ileocæcal angle, no communication was found with the lymphatics of the pelvis, but a few vessels were found to pass into the retroperitoneal space of the right iliac fossa It was found repeatedly, however, that an injection into the appendix would send the dye inwards to the

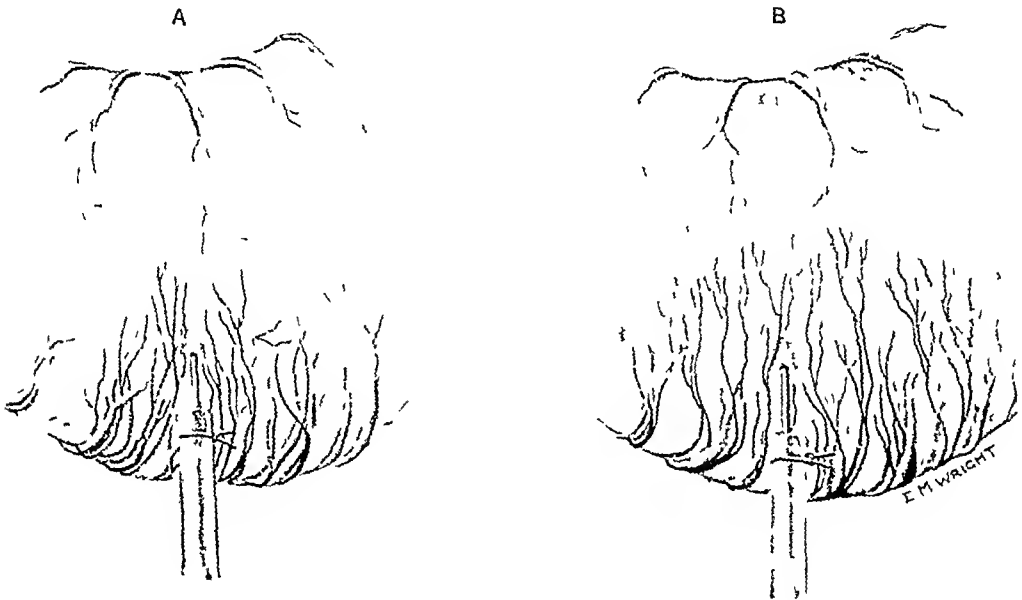


FIG 7—A shows view of stomach wall injected in dead, and B in living subject under similar pressure

small intestine and, at a higher level, outwards to the ascending colon (aberrant and retrograde flow) On rare occasions an appendiceal injection, passing through gland after gland in the ileocæcal chain would fill the group of glands round the trunk of the superior mesenteric artery, but no more, after frequent injections into the appendix it was noted that injection into one of the ileocæcal glands was a more certain method of colouring this group The entry and exit of lymph to and from the glands round the trunk of the superior mesenteric artery where it crosses the third part of the duodenum being the immediate object of the inquiry this method of accomplishing then injection was very largely used

It may be said at once that injection of the glands on the greater curvature of the stomach near the pylorus (Jamieson and Dobson's 'right gastro-epiploic group') was never achieved through the ileocæcal chain though as we shall

see later, it was achieved in another way. It should, however, be understood that connecting links—though in theory they are efferent paths—do in fact exist. Pomeroy and Chaipy⁷ describe not only close connection between the glands on the greater curvature near the pylorus and the group of glands which

lies in the angle between the first and second parts of the duodenum, in front of the head of the pancreas (Jamieson and Dobson's 'subpyloric group'), but also a further path along the right gastro-epiploic vein directly to the superior mesenteric group.

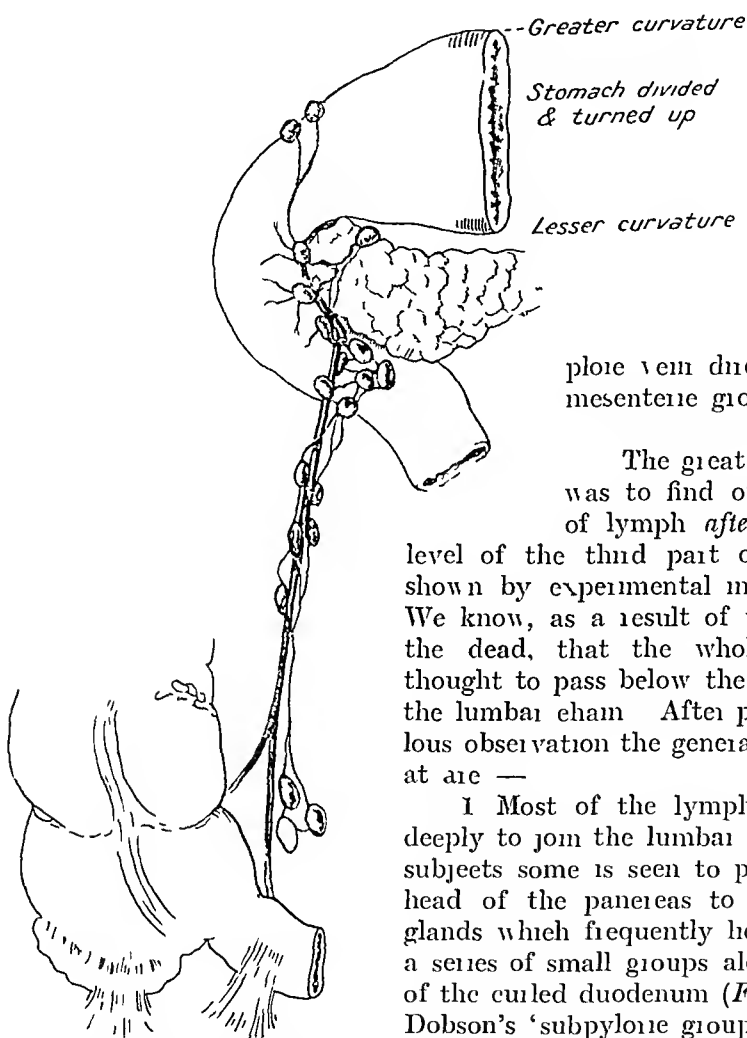


FIG 8—Diagram showing area of glands injected in the living subject from an ileocecal gland puncture

The great object of the inquiry was to find out what is the path of lymph *after* it has reached the level of the third part of the duodenum, as shown by experimental injection in the living. We know, as a result of very careful work in the dead, that the whole of the lymph is thought to pass below the pancreas straight to the lumbar chain. After prolonged and scrupulous observation the general conclusions arrived at are—

1 Most of the lymph undoubtedly passes deeply to join the lumbar group, but in living subjects some is seen to pass upwards *over* the head of the pancreas to enter that group of glands which frequently lies in a crescent or in a series of small groups along the inner border of the curled duodenum (*Fig 8*) (Jamieson and Dobson's 'subpyloric group')

2 Some undoubtedly passes *through this group on to the duodenal wall itself and up to, and occasionally beyond, the pylorus*. The injection has been seen on two occasions to pass even higher, reaching the chain of glands along

the common bile-duct, and even colouring the cystic gland

Post-mortem Experiments—Experiments were now made in young human subjects, post mortem, by the use of Gerota's Prussian blue and the mercury pump (8 to 10 mm Hg), an attempt being made to reproduce the injections already accomplished in the living. They were not nearly so uniformly successful

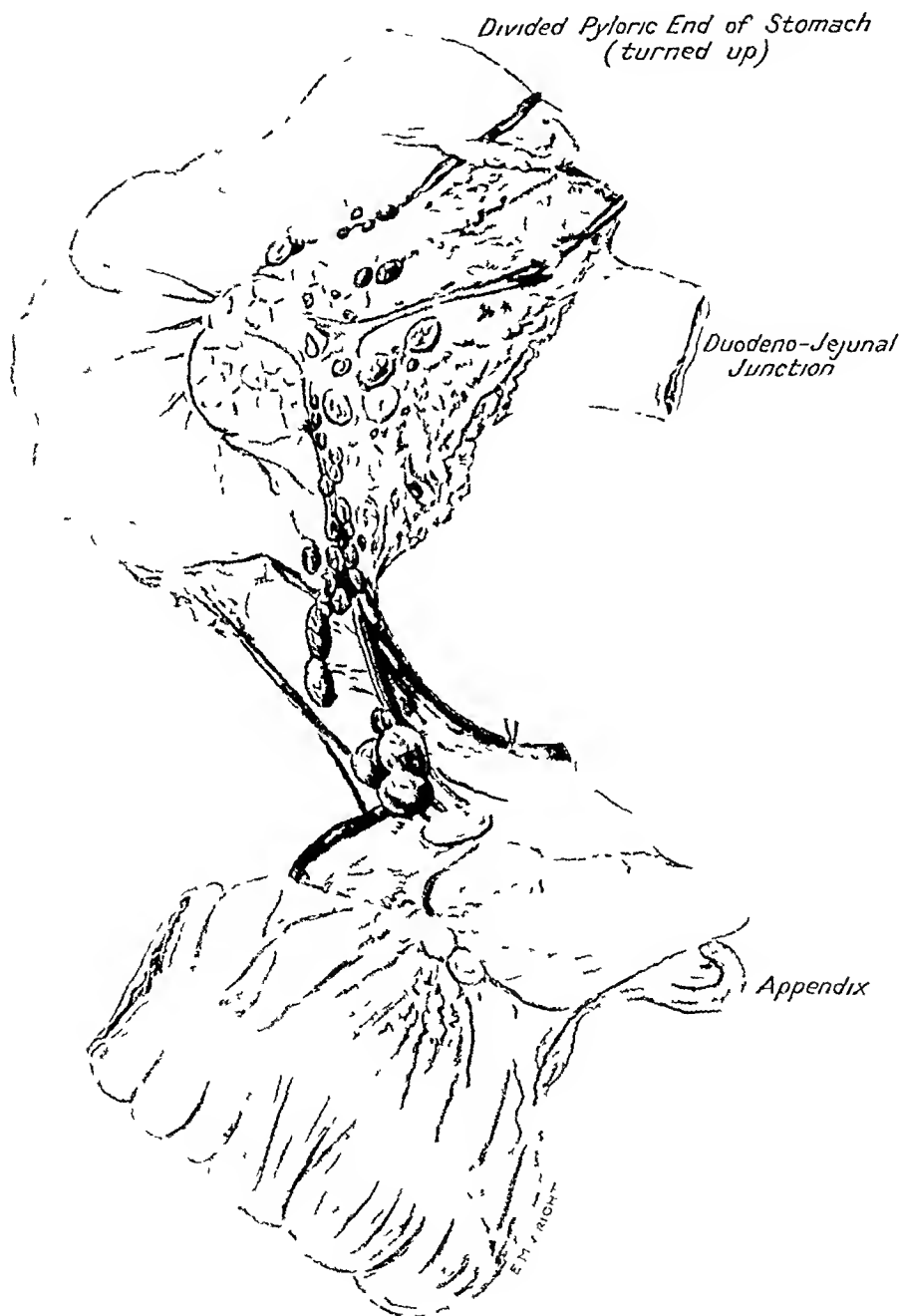


FIG. 9.—Drawing of an injected post mortem specimen (the needle was placed in an ileocecal gland). Retrograde flow back to the cecal wall is clearly shown.

Fig 9 shows injection of the crescentic group of glands on the head of the pancreas near the duodenum quite well, though in the living subject they are more clearly marked, they were made into an ilcoæcal gland. The line of injection appears to follow fairly accurately the arc made by anastomosis of the superior and inferior pancreaticoduodenal vessels, though a much more irregular distribution is common. It would therefore appear possible to inject, both in the living and the dead an area much wider in extent than would be expected from a study of the 'normal' anatomical paths apparently followed by the lymph flow.

Can the discrepancy between these experimental findings and the usual text-book description of lymph flow in this area be accounted for by an unusual success on the part of the investigator in his injections in the dead and living subject, opening up paths hitherto not known? It is certain that, although the flow of lymph is very adequately described by many writers as from the periphery of each great lymph-shed to its termination in one or other of the big groups of glands on and near the head of the pancreas, the possibility of connections existing between the termini themselves has never been investigated. It is possible that there are in existence reserve sets of lymph channels as well as lymph glands, which come into play (1) Under unusual pressure of lymph flow, and (2) In the presence of obstruction in the normal channels, due to disease.

Stiles⁸ describes very minute glands, 1 to 2 mm in diameter, possessing a very primitive structure and consisting of a single lymphoid follicle connected with one afferent and one efferent lymphatic existing normally in the axilla, which are not described as occurring amongst the usual axillary glands. He thinks them capable of becoming properly developed glands and of taking the place of glands removed by operation or put out of action by disease. Such a possibility—also dwelt upon by C. H. Mayo—is of considerable interest and importance in considering the question of aberrant and retrograde lymph-flow in the presence of long-standing infection.

THE EFFECT OF DISEASED GLANDS ON THE LYMPH FLOW

Experiments were made in the living subject on the effect of diseased glands on lymph flow. A lymph gland was drawn up from the mesenteric surface, and its base was very tightly ligatured, the ligature exerted a similar effect to that produced by a chronic lymphadenitis (*Fig 10*). In every experiment in the living subject injection made into the gland next below the ligatured gland failed to enter the ligatured gland, and after a moment's hesitation a new sheaf of aberrant vessels came into play, which carried the injection fluid round the ligatured gland to the gland next but one or more above it, in addition, the injection sometimes flowed backwards towards the gland below. We produced, therefore, a retrograde as well as an aberrant flow of lymph. In four cases, where an obvious old tuberculous gland was found injection was made into the next healthy gland below, of the same chain. In all the cases it was clear that the diseased gland acted as an obstruction, sometimes there was partial permeation of the gland, its surface presenting a chessboard pattern of blue and white squares, sometimes an

effluent vessel would become injected in addition to one or two afferents, sometimes there was no flow whatever into any area within one-half to one inch of its periphery the afferent vessels appearing to stop at a blind end. It was never found possible to reproduce these experiments post mortem.

Cornet's law of localization lays down that infection—in a previously healthy lymphatic system—within lymph channels, always travels from one regional group of glands to the next regional group in the direction of the lymph flow. Retrograde flow of lymph in a healthy subject is denied as a possibility by most writers and probably this is true to a very great extent, but it is certain that it may take place, and was—as is seen—often noted in the course of the experiments even in apparently healthy subjects.

Most, of Bieslau⁹ says that retrograde flow can only occur when there is serious disturbance of circulation. He illustrates retrograde flow in a coloured drawing, as occurring from a septic sore on the leg, the lymphangitis spreading chiefly up the leg, but also for some inches downwards.

In Moynihan's book *Abdominal Operations*,⁵ he states: "In cases of cancer (stomach) the early involvement of certain lymph vessels, then plugging by cancer-cells, or the implication of a single gland, may be enough to disturb the normal direction of the lymph current." Sampson Handley has shown that metastases from a carcinoma of the breast may pass down to the rectus sheath and so to the liver. He has also reported that carcinomatous cells from a rectal growth can be found six or eight inches below the primary growth, though this is denied by later workers (Cole

Monsarrat and Williams, and Cheatle). Every surgeon must know the frequency with which the glands along the common bile-duct become enlarged in cases of carcinoma of the stomach, this can only come about by retrograde lymph flow. Is it not more than possible that secondary carcinoma in the liver arising from both stomach and intestinal canal may have passed along lymphatic vessels by retrograde flow?

McVay⁹ says rectal carcinoma may reach the liver through glandular metastasis or by breaking off of emboli of carcinoma-cells into the portal circulation. Joseph Wiener¹⁰ considers it possible that the ileocæcum may be secondarily infected by retrograde flow from diseased mesenteric glands. Broders¹¹ describing a case of gastric tuberculosis, quotes Claytor and

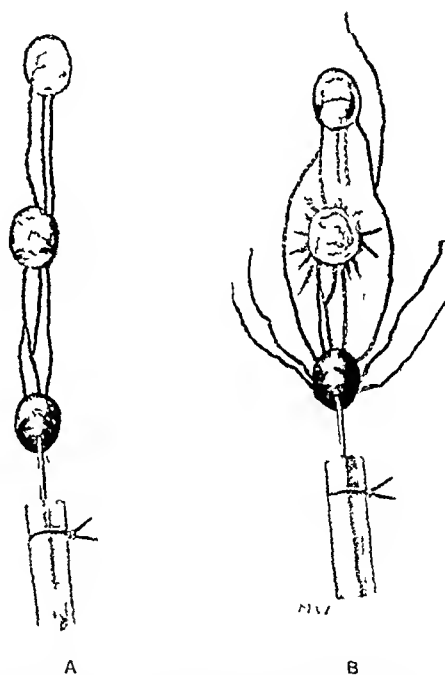


FIG. 10.—Shows (A) the normal injection of a chain of glands, and (B) the effect of ligation of the middle gland.

Wilkinson as considering that tuberculosis may affect the stomach from adjacent tuberculous glands. He also states that Chian had a case of a similar kind. Rosset thought his case of tuberculosis of the stomach was due to a primary focus in the lymph glands at the hilum of the left lung and that it infected the retrogastric lymph glands and then the stomach by a blockade of the lymph stream. The late Edward Ward of Leeds used to illustrate the very free collateral circulation of lymph and the presence of aberrant flow as a result of disease by the condition seen in cases of malignant disease developing in a long-standing lupus (usually facial). Owing to the sclerosing of normal lymph channels by tuberculosis the superadded malignant disease is unable to reach the lymph glands and they do not in fact become enlarged. As soon as the malignant disease reaches healthy skin, the lymph nodes become affected sometimes on the same side of the neck but frequently on the opposite side.

Last month a lady was seen in consultation with Dr. Hall. She presented an interesting picture of retrograde lymph flow. As a V.A.D. during the war she had suffered repeatedly from septic fingers chiefly in the left hand and presumably from lymphangitis and lymphadenitis. She was recently vaccinated in the usual place in the upper part of the left arm, and after ten days developed acute suppuration in the tendon sheaths in front of the wrist of the same side. There was no appreciable lymphadenitis in the axilla, and no sign of any septic focus except the vaccination spots.

Most¹² suggests that a tumour forms in growing new lymphatic sheds with new channels for evacuation. Thus it is possible for new glandular regions to be infected by way of these new vessels (aberrant flow). Gerota himself, in a case of carcinoma of the breast with metastases in the inguinal glands, determined, by actual injection at the post-mortem, the newly-formed lymphatic tract.

It might be argued that to illustrate retrograde lymph flow by the spread of carcinoma is not a fair thing, because it is not so much a flow as a permeation. It is true that at the edges of a carcinoma lymph channels are seen blocked by an unbroken line of malignant cells, but Sampson Handley and others have shown that at a distance from their source the cells lie in the lymph channels in solitary masses with stretches of normal lymph vessel intervening. This would certainly suggest that both a permeation and a flow are present: first a permeation, then a 'wasting away' of the outlying cells by the fluid lymph.

We shall see later that, assuming the text-book description of lymph flow to be correct, the view that there is a retrograde or aberrant flow of lymph must be accepted before any reasonable theory of the existence of a lymphatic flow from the ileocaecal angle which could give rise to gastric or duodenal ulcers can be entertained. Lymph must not only pass to the glands which guard the stomach and duodenum, but find its way *beyond* them.

Injection of the Glands along the Right Gastro-epiploic Vessels—One of the most striking results of this investigation was achieved by an accident. In commencing an injection with indigo-carmine into the caecal wall of a living cat some of the dye escaped into the lower part of the abdominal cavity, as

the experiment proceeded it was noted that the glands in the subpyloric region had become injected before the glands in the upper part of the ileocolic chain. An investigation showed that the dye had been taken up by the great omentum and delivered into this gland. Further and similar experiments with both indigo-carminic and Chinese black were convincing that the subpyloric glands in cats acted as the great portal through which the peritoneal cavity in its lower part passed its effluent.

Investigations in living man on somewhat similar lines presented great

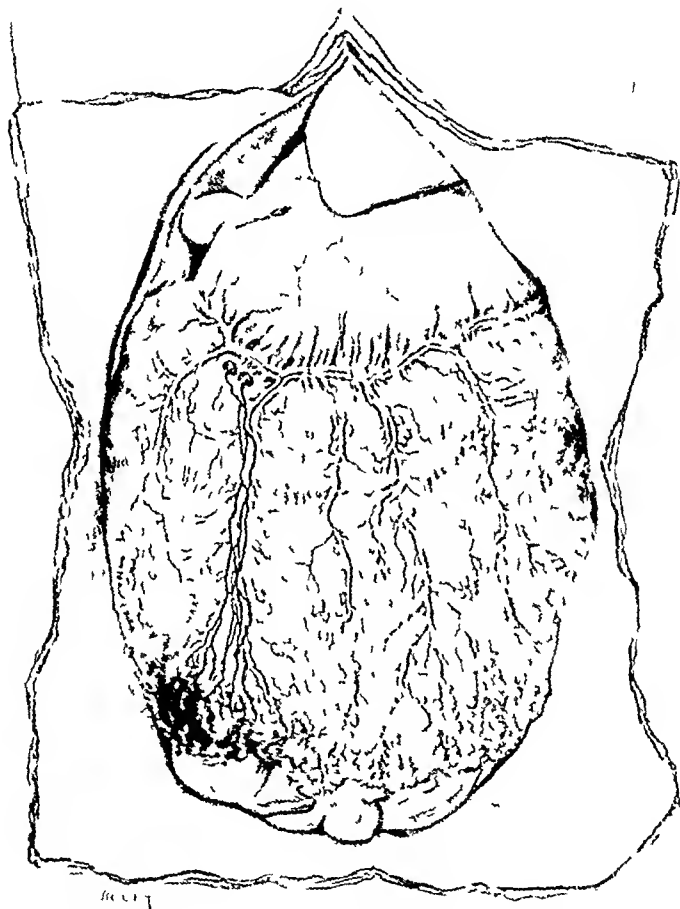


FIG. 11.—Showing flow of dye through omental lymph vessels to glands.

difficulties. It was seen early that something more than contact of the indigo-carminic with the free margin of the great omentum was necessary, it was necessary to combine it with massage. The time taken for the dye to reach the right gastro-epiploic glands was found to vary very widely, it never arrived there under one hour, and much more often failed to travel more than an inch or two in this space of time. Clearly the attempt could only be made when a major operation was in process—gastric cases could not be utilized at all. Nearly all the experiments were therefore made in cases of gall-stone

disease In the performance of choledochotomy for common-duet stone the left forearm of the operator, and to a lesser extent the right, come to lie over and exert an intermitting pressure over the lower abdomen It was in this class of case that the whole of the successful results were obtained A large piece of gauze was soaked in indigo-carmin (1-60) and fixed by clips to the lower free border of the great omentum, the omentum with the attached gauze was then returned to its place in the abdomen and the operation continued After an average time of from one to one and a half hours, streaks of the dye could be seen slowly rising along the course of the main blood-vessels of the omentum, crossing the transverse colon and emptying into the right gastro-epiploic glands (*Fig 11*) Out of twenty-one attempts made in suitable cases, only four were successful With a wider distribution of the dye, two groups of lymph vessels were clearly seen, converging one to the right side of the greater curvature of the stomach and one to the left, the former filling the more rapidly and being the more clearly marked Despite many efforts, the injection was never seen to pass through the right gastro-epiploic group on to the wall of the stomach

The great omentum, therefore being the great scavenger of the abdominal cavity—Moynihan calls it the great drain-pipe—is able to pick up probably through open lymphatic terminal spaces, morbid material and to convey it upwards to the greater curvature of the stomach, where it passes chiefly into the group of glands towards the pylorus and in a smaller measure into those glands near the hilum of the spleen

In connection with this work, Wilkie's¹³ monograph is most interesting He says "The extraordinary faculty possessed by the omentum for plastic adhesion to any zone of peritoneal irritation, and thus for walling off and localizing inflammatory processes is so constantly evident to the surgeon and to the pathologist, that they have almost come to regard the great omentum as a purely beneficent agent in abdominal pathology Notwithstanding its peculiar capacity for rapid reaction and repair, it would, indeed be strange if the omentum could take part in so much inflammatory trouble and yet come out scatheless That a chronic inflammation of the omentum may remain after the primary seat of infection has healed has been repeatedly demonstrated, but that the omentum may form the channel by which the pathological process may be carried to other organs is a fact that has hitherto received but scant recognition The intimate anatomical relations of the omentum with the stomach and the first part of the duodenum especially in regard to their vascular supply, suggest the possibility of morbid conditions in the former spreading or being conveyed to the latter through their vascular connections "

Wilkie then suggests that the omentum being infected by its presence in the region of the appendix, sometimes by its actual adhesion, becomes inflamed and its vessels thrombosed, he further suggests that emboli pass from these vessels to the stomach and duodenum and give rise to ulceration, he also considers that gastric erosions—by some authors confused with ulcers—thought to be the cause of hæmatemesis, and seen frequently in the absence of the real and visible ulcer, may be due to a similar pathological process, possibly to a spreading lymphangitis in the great omentum The experiments described would certainly add weight to Wilkie's views

POSSIBLE BEARING OF THE LYMPH FLOW ON THE CAUSE OF DUODENAL AND GASTRIC ULCER

In considering what effect the investigations described may have on the causes of duodenal and gastric ulcer and of other forms of dyspepsia, obviously it must first be granted that the right iliac fossa is capable of producing either a toxin or an infective agent. Lane's views on this question are too well known to need any repetition. It is not within the scope of this inquiry to fix on the exact origin of the trouble, it may be the appendix, it may be the cæcum or the small intestine. There can be no doubt the appendix is the most likely of the three.

In order that the morbid effluent may reach the duodenum it should certainly pass along the lymphatic tract indicated by the experiments described. Assuming lymph to flow as described by those who have worked most on the anatomy of the lymphatic system, it is clear that in the absence of retrograde or aberrant flow, it can never reach the duodenum. The experiments on apparently normal young post-mortem subjects—i.e. normal in regard to this tract—would appear to show that there is an easy way up to the duodenal border, and that apart from retrograde or aberrant flow. It would seem that the large groups of glands lying on or near the head of the pancreas, with the group on the superior mesenteric trunk, act normally as one big receiving station, with extensive backward and forward communications within the limits of the station—something analogous to the circle of Willis at the base of the brain, allowing lymph, hindered in its flow in one direction to pass in another.

Let us assume that we start with perfectly healthy lymph vessels and glands. For some reason or other there comes pouring into the mesenteric group of glands a stream of infected lymph, the result is bound to be a lymphangitis and a lymphadenitis spreading upwards from node to node with a gradually decreasing effect as it nears the last line of gland sentinels before reaching the blood-stream, assume the flow still goes on over a period of months or years. It is not too much to suggest that chronic obstructive lymphangitis and lymphadenitis develop, most markedly nearest the origin of the infection, but gradually involving the whole lymph-shed. The result of this change would be obstruction in the path of the normal flow. Gradually the whole mechanism is thrown out of gear, and we have everything present to give rise to aberrant and retrograde lymph flow. Now the infected lymph, failing to make its usual exit, seeks new avenues of escape in all directions, misses whole groups of glands which under ordinary conditions would check and filter it, and ebbs and flows to and fro until the glands around the superior mesenteric artery are reached and partly obstructed. Deprived of easy access through them to the lumbar glands, part of the lymph flows onwards over the head of the pancreas and enters the glands on the concavity of the duodenum, and in process of time bathes even the duodenal wall itself escaping finally to the celiac glands by normal or possibly aberrant paths and so reaches the receptaculum chyli.

Is it not a reasonable suggestion that similar infective lymph may pass along the great omentum, and—through a similar process of obstruction in the right gastro-epiploic glands—reach the stomach? It is certainly a fair supposition in those cases where actual adhesion of omentum to the morbid

focus in the right iliac fossa has occurred, but what of those cases where there is no direct union to the omentum? What is it that takes place in an attack of acute appendicitis? There is poured out a great quantity of fluid at first of bacteriæidal potency but quickly becoming contaminated. The results of the subsequent inflammation are not confined to the appendix itself, but are frequently many inches away from it as is shown by bands and adhesions in the neighbourhood. If this be true of acute appendicitis, may it not be true to a lesser extent of the subacute or even chronic variety?

One would venture, then, to suggest that the infective fluid is actually poured out into the general peritoneal cavity and carried in part up the great omentum to the stomach, and, as Wilkie suggests, also to the first portion of the duodenum. Is it not also possible that any infection in the abdominal cavity, the result of which is the exudation of contaminated fluid, may produce an exactly similar condition—an ascending lymphangitis in the great omentum with the same clinical and pathological results?

Following then the presence of infected lymph along the greater curvature lasting for months or more a state of chronic lymphangitis and lymphadenitis develops with resulting lymph stasis, possibly an incompetency of valves aberrant and retrograde lymph movement and (as has been said) the stomach becomes lavied by an infected fluid.

It has not been forgotten that the right gastro-epiploic glands are frequently found enlarged as a result of œmionia of the stomach, and also as a result of simple ulcer, nor has it been lost sight of that one of the afferent paths of these glands must be gastric the other being naturally omental, it is not pretended that gastric erosions alone (apart from ulcer) may not cause a lymphadenitis, both on the lesser and, to a smaller extent, on the greater curvature. It is unusual however to find the groups on both curvatures enlarged together except in the presence of visible and palpable gastric disease. One can well imagine a small gastric lesion, or a series of small gastric lesions (erosions) set up by a flow of infective lymph arriving via the duodenal lymphatic vessels, giving rise to enlargement of the right gastro-epiploic group of glands. When there are two groups of right gastro-epiploic glands a small upper and a larger and more numerous lower, except in the presence of obvious ulcer, it is almost always the lower group below the vessels, which is enlarged i.e. the one furthest from the pylorus.

It is admitted that to accept all this without further proof needs considerable credulity and some courage, but even assuming it be accepted provisionally and for the moment gastric and duodenal ulcer, and possibly gall-stones, are not of necessity due to it.

1 Duodenal Ulcer—The presence of infected lymph in the walls of the duodenum would give rise to different conditions depending upon the acuity of the infective agent—an acute dose of a severe infection might give rise to a catarrhal jaundice, a chronic one to a 'duodenal' dyspepsia, a slow infection of a milder type would give rise to inflammation and erosion of lymph follicles in the duodenal wall. This erosion would be likely to be countered by bile and pancreatic juice since they are alkaline, and so would not give rise to ulceration below the bile papilla and the erosions would speedily heal up. That portion of the duodenum most likely to suffer would be above the

bile papilla, where the contents are acid, and would be in the area least supplied with blood i.e., Mayo's anæmic spot on the anterior wall of the first part of the duodenum towards the upper or antimesenteric border and this, of course, is the usual place for a duodenal ulcer. It is in this area also that most of the masses of lymphoid tissue are normally present.

2 Gastric Ulcer—Assuming the pyloric half or third of the stomach to be bathed from time to time in a wave of infected lymph, how can this produce the usual type of gastric ulcer in the usual situation? The early effect on the stomach would be congestion (pyloric blush) with hypersecretion, hyperacidity, and spasm—the conditions found to be present in appendix dyspepsia (Moynihan¹ and Paterson²). Later on, multiple gastric erosions would occur perhaps giving rise to hæmatemesis (the common type of so-called 'gastric ulcer'). Bolton¹⁴ says "Perhaps the commonest cause of hæmorrhage into the mucous membrane is bacterial infection—either by direct action of the bacterial poison on the capillary wall, or by giving rise to vascular occlusion and hæmorrhagic infarction. In the latter case necrosis of tissue is always present, in the former it may not be." Letulle¹⁵ certainly produced gastric ulcers by inoculation of the general peritoneal cavity by the *Staphylococcus pyogenes aureus*, probably via the great omentum. Relics of a bacterial infection are to be found in the crater of many gastric ulcers (Bolton, Balfour). Acute ulcers are known to occur in many infective diseases, e.g. puerperal fever, peritonitis, pleurisy, tuberculosis (Jaksch, 1844). All or most of the erosions would heal during a temporary lull in the flow of infection but one or more might remain to become a true gastric ulcer.

Why, then, should the effects of the poisoned lymph be permanent only on the lesser curvature and near the pylorus? (1) It is in this place that lymph follicles are twice as numerous as, and are bigger than, in any other portion of the stomach (Bolton), (2) The lesser curvature is the chief channel for the transmission of the contents in a stomach which is not full (Lewis), (3) The lesser curvature is the antimesenteric border, the ulceration thus coming into line with the usual antimesenteric ulceration seen in other parts of the gastro-intestinal canal—possibly due to a decreased blood-supply.

If, then, ulcers of stomach or duodenum be due to infection received from the appendix, the elimination of the offending organ might be expected to cure the ulcer. There is no doubt appendicectomy frequently cures an indigestion which cannot be differentiated from duodenal or gastric ulcer. Bolton and Stewart¹⁶ have shown that there are frequently many scars of healed ulcers present post mortem, and there can be no doubt that most cases of chronic indigestion are accompanied by curable ulceration. Assuming, however, that a really well-marked ulcer is developed, the presence of free HCl, and the persistence of trauma and mobility, may cause it to be intractable even in the event of the original cause being cut off. The constant desire of the ulcer to heal is seen in the presence of massive fibrous barriers which frequently surround it, as well as in the typical periods of symptomatic quiescence.

If, then, there are grounds for believing that duodenal and gastric ulcers can arise in this way, are there not almost equal grounds for attributing the *B. coli* infection of the gall-bladder to a similar phenomenon?

Cases showing actual and obvious pathological extension by a direct lymphatic connection from the ileocaecal angle to the region of the pyloric end of the stomach are not far to seek. The pigmented-gland case has already been described. Moynihan recently, whilst engaged in an abdominal operation, found a mass of tuberculous glands in the ileocaecal angle, a complete chain up to the third part of the duodenum, and in addition a chain running along the common bile-duct, so far had the process of calcification proceeded in the latter group that he was momentarily led to the belief that he had to deal with stones in the common bile-duct. Carlton Oldfield had a similar case. Gordon Taylor quite recently related a remarkable case in which the patient, having previously had a gastro-enterostomy performed, developed the signs and symptoms of perforated gastrojejunal ulcer in the line of the anastomosis. Operation revealed the perforation with a generalized peritonitis. As part of a routine examination the appendix was examined, and found to be in the stage of acute gangrenous inflammation. This case would suggest infection of the posterior wall of the stomach from a flow of highly-infected lymph. Moynihan has related several cases of the co-existence of acute appendicitis and acute cholecystitis occurring in his own practice.

The investigation described would lead one to suggest that a new anatomy of the living as well as a new pathology of the living, or the two combined, might be deemed at any rate worthy of serious consideration.

The author desires to acknowledge the kindly interest and assistance given him in the preparation of this paper by Dr R. A. Veale, Mr J. T. Blackburn, Professor M. J. Stewart, and the Medical and Pathological Departments of the University of Leeds. The X-ray photographs were taken and very kindly lent by Dr Leo A. Rowden.

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ON UNILATERAL FUSED KIDNEY AND ALLIED RENAL MALFORMATIONS.

BY M J STEWART AND S D LODGE, LEEDS

(From the Department of Pathology and Bacteriology, Leeds University)

AMONG the many developmental anomalies to which the urinary apparatus is subject, that of fusion of the kidneys occupies an important place. It is met with in two forms of which one, the horseshoe kidney, is common, while the other the 'concreescent' kidney of Géraid, is rare.

In the horseshoe group the kidneys occupy more or less their normal position in the body, but are united across the middle line by a bridge of renal or, less commonly fibrous tissue. In the great majority of cases it is the lower poles which are so joined, exceptionally the junction is at the upper poles. Of 90 cases collected by Géraid (1905),⁶ 83 belonged to the former class, and only 7 to the latter. Morris (1901),¹³ in a search through the records of four London hospitals, found 19 cases of horseshoe kidney in 18,244 post-mortems. In a series of 6500 post-mortem examinations at the Leeds General Infirmary there were 14 cases of horseshoe kidney, all showing fusion below.

The 'concreescent' group of Géraid consists of cases where, as a rule, renal fusion is much more extensive, and where there is more or less asymmetry of renal tissue, with absence of the horseshoe form. It is further subdivided into those cases where the fused mass is, in part at least, prevertebral, and those where it is definitely and completely unilateral. We have ventured to add a third variety, the pelvic fused kidney.

This classification based on Géraid, may be shown thus —

Table I—FUSION OF THE KIDNEYS

- | | | |
|---|-----------------------------|-----------------------------------|
| 1 | The horseshoe kidney — | (a) Fusion at upper poles |
| | | (b) Fusion at lower poles |
| 2 | The 'concreescent' kidney — | (a) The prevertebral fused kidney |
| | | (b) The unilateral fused kidney |
| | | (c) The pelvic fused kidney |

The classification here suggested is an important one from the clinical standpoint, and is to be preferred to the purely morphological subdivision of class 2 (above) into sigmoid kidney, where there is more or less end-to-end anastomosis, and disc-shaped kidney, where the amalgamation is much more complete (Morris 1901,¹³ Newman, 1898¹⁴). As used by Newman, however, the terms practically correspond: sigmoid kidney with unilateral fused kidney, and disc-shaped kidney with prevertebral fused kidney. Disc-shaped kidney, on the other hand is sometimes unilateral.*

* The terms 'unsymmetrical kidney' and 'solitary kidney', meaning respectively congenital absence of one kidney and fused kidney, formerly much in use, seem to us merely misleading. Fused kidney, for example, may be 'unsymmetrical', as in the case described in detail in this paper.

Gérard collected 8 cases of prevertebral fused kidney from the literature, and 14 of the unilateral type. He also refers to 4 cases of pelvic fused kidney, those of Cruveilhier, Dubor, Carrién, and De Rouville. A fifth instance from the Museum at Guy's Hospital, is given by Wilks and Moxon (1889).¹⁹ The only other case of this kind of which we have found a record is one mentioned by Duckworth (1869).⁵ He says, "I have found the notes of one (case) where there was only a right kidney present. It was an intrapelvic organ in this instance, however. The specimen is in the Pennsylvania Hospital Pathological Museum. It has two ureters, which enter the bladder at the usual place, and two renal arteries. The general outline of the organ is described in the catalogue as circular." We have been unable to find any published account of this case beyond Duckworth's brief reference, and while the description of the ureters is ambiguous, it seems at least highly probable that this is an example of pelvic fused kidney.

In our own series of 6500 autopsies we have met with but one example of unilateral fused kidney and none of the other two varieties. Morris found "one fused kidney other than horseshoe-shaped" in 15,908 autopsies.

Table II—INCIDENCE OF CONGENITAL RENAL ABNORMALITIES IN A CONSECUTIVE SERIES OF 6500 AUTOPSIES

TYPE OF ABNORMALITY		NO. OF CASES	INCIDENCE
1	Horseshoe kidney	14	0.21 per cent
2	Unilateral fused kidney	1	
3	Congenital absence of kidney—		
	Right absent	4	0.24 ,
	Left absent	12*	
4	Pelvic kidney	3*	0.04 „

* One case is common to these two groups

By contrast with these anomalies, the *congenital absence* of one kidney appears to be fairly common. Gérard collected no fewer than 279 cases from the literature, and in our series there were 16 cases. Morris, on the other hand, found but 6 cases in 15,904 autopsies from Guy's Hospital, the Middlesex Hospital, St Bartholomew's Hospital, and the Hospital for Sick Children, Great Ormond Street. Apparently 3 of these were regarded as cases of congenital absence, and 3 as examples of extreme atrophy or extreme want of development. According to these figures, absence of a kidney is met with once in every 2650 post-mortems, whereas in our series the incidence is one in every 400. From the practical standpoint it makes little difference whether the absence of the kidney is due to purely developmental defect or to extreme atrophy during foetal life. Nevertheless, in our series of 16 cases we feel confident that at least the great majority are examples of genuine congenital (developmental) defect. In the first place, careful naked-eye examination failed to reveal even the tiniest shred or relic of renal tissue

on one side of the body. In the second, it is specifically noted in 5 cases that the ureter on that side was also lacking, and that in 3 of these there was no sign of an orifice or plica ureterica on the corresponding side of the bladder. In the third place 5 cases (4 of them other than those with absence of the ureter) showed other important developmental abnormalities viz., absence of homolateral adrenal (1 case), bicornuate uterus (1 case), absence of homolateral testis (1 case), and imperfectly descended testis (2 cases).

1 Horseshoe Kidney—All the cases of horseshoe kidney were of the usual type—the organs fused at their lower poles by a thick band of renal tissue. The ureters invariably passed down in front of the fused organ. In the cases in which there was any displacement, the kidneys merely occupied a slightly lower position than usual in the body or approximated more nearly to the middle line. No other developmental abnormalities were noticed in these cases.

The age of these patients is of interest as showing that the possession of a horseshoe kidney is no bar to long life. The average age at death is 47 years. One patient died at 82, following an operation for strangulated inguinal hernia. Two patients were aged 60 to 70, five 50 to 60, two 30 to 50, and two 20 to 30 while the youngest was 14. This compares very favourably with the general age-distribution of the 6500 autopsies. In only one case was there gross kidney disease—chronic nephritis in a woman of 27.

2 Unilateral Fused Kidney—This case is referred to in detail later, it is sufficient to say here that the condition was unaccompanied by any other congenital malformation nor was it related to the death of the patient.

3 Congenital Absence of one Kidney—As shown in *Table II*, the incidence of this defect in the present series is much the same as that of horseshoe kidney. The much greater frequency of left-sided defect (3-1) is not quite in keeping with Gériard's larger series of cases. There, in the 232 cases in which the side is mentioned, the left kidney was absent in 136, the right in 96, a ratio of $3\frac{1}{2}$ to $2\frac{1}{2}$. Sex-distribution is also unequal. In our series there were 14 males and 2 females. In Gériard's collected cases there were 122 males and 93 females. This latter discrepancy may be accounted for by the fact that more males than females come to post-mortem.

The weight of the single kidney is usually above normal, but rarely reaches that of two healthy kidneys. In our cases the usual description is that the organ was 'slightly enlarged' or 'moderately enlarged'. Of six adult kidneys weighed, the largest was 10 oz., and was the seat of subacute nephritis, three were between 7 and $7\frac{1}{2}$ oz., and two were $3\frac{3}{4}$ and $2\frac{1}{2}$ oz. respectively. The last was the seat of advanced chronic interstitial nephritis.

As compared with the cases of horseshoe kidney, the incidence of renal disease is high in this group. In 6 out of the 16 cases, the death of the patient was directly attributable to disease of the solitary kidney. There were 3 cases of subacute and chronic nephritis, 1 of calculous pyelonephritis, 1 of tuberculosis, and 1 of ascending pyelonephritis following cystitis. This, of course, is a much higher incidence of renal disease than in the average run of post-mortems. In the remaining 10 cases there was no evidence to show that absence of one kidney had any connection whatever with the death of the patients. Two died in infancy and 3 in childhood, but of the remaining 10

no fewer than 6 were 55 years of age or over. The oldest patient was 81, and he died from a fractured skull.

The average age at death in this group is 36.5 years, but if the two infants, who died of rickets and hydrocephalus respectively, be deducted, the figure is 42.5, as compared with 47 years in cases of horseshoe kidney.

Statistically these figures are too few to be reliable, but they tend to show that the possessors of a single kidney are shorter-lived and more prone to renal disease than those who have either a pair of kidneys or a horseshoe organ. Unfortunately this aspect of the subject is not touched on by Géraid.

The frequency of other congenital malformations, especially of the genital tract in cases of congenital absence of the kidney, is insisted on by all writers on this subject (Géraid etc.). In one of the two female cases in our series there was a bicornuate uterus. In 3 of the 14 male cases there were testicular abnormalities on the same side as that from which the kidney was missing. In one of them the testis was absent, in another it was in the inguinal canal, and in the third it lay in the abdomen at the outer edge of the psoas muscle. It is fairly certain, moreover, that in some of our cases the genital tract was not carefully examined, and in this way defects may have been missed. Of 8 cases where the adrenals are specifically referred to in the post-mortem report, in 7 these glands were normally situated, in 1 the homolateral adrenal was missing.

4 Pelvic Kidney—Two of these cases are of the usual type. One kidney (the right), malformed, was situated in the pelvis and obtained its blood-supply by a short renal artery springing from the abdominal aorta at or near its bifurcation. The patients were a male of 53 and a female of 66, and in neither was the renal condition in any way related to the cause of death. The third case is a very unusual one, and worthy of fuller notice. Here the left kidney was congenitally absent, and the solitary right kidney was situated in the pelvis. It was connected to the bladder by a short, knicked ureter only 3 inches in length, and obtained its blood-supply by a single large artery given off at the bifurcation of the aorta. The left ureter, like the kidney, was non-existent. The patient, a man of 55, died of an acute ascending pyelonephritis following cystitis of unexplained origin.

This condition must be very rare. The only case of the kind mentioned by Géraid is that of Polk (1883),¹⁵ which is of extraordinary interest in that the solitary (ectopic) kidney was removed surgically. The patient, a girl of 19, had a movable and painful tumour in the left iliac fossa. It was oval, with its long axis directed downwards and inwards. The genital organs were rudimentary, the uterus and vagina being absent. The tumour was thought to be kidney, and as it was easily accessible and seemed to be the seat of the violent pain of which the patient complained at each menstrual period, it was removed. The organ, after excision, appeared healthy and weighed 198 gm. Death ensued eleven days later, and at autopsy it was found that the right kidney and ureter were completely absent.

In addition to the 3 cases of pelvic kidney just cited there is, in our series, 1 case in which the fixed and displaced organ lay just above the brim of the pelvis. It has not been included in the statistical table.

Pelvic kidney may occupy either a median or a lateral position, and it is invariably much deformed. Where the kidney sits on the pelvic brim it usually lies over one or other sacro-iliac synchondrosis.

REPORT OF A CASE OF UNILATERAL FUSED KIDNEY

Except for the fact of its obvious rarity, the unilateral fused kidney is a condition of great clinical interest and importance, and, inasmuch as the ureters in these cases invariably open normally into the bladder, the true state of affairs, even after careful cystoscopy may easily be missed. The following example illustrates very well the possible value of pyelography in such cases.

The patient was a man of 56 years, who died of acute generalized peritonitis following left inguinal colostomy for annular carcinoma of the sigmoid flexure. There were early metastatic deposits of growth both in the liver and in the abdominal (pre-aortic) and mediastinal lymph glands.

Kidneys—There is no renal tissue on the left side of the body, although the left adrenal is normally situated. The right kidney (*Fig 12*) is apparently enlarged, measuring $16.5 \times 7.5 \times 4$ cm in its three principal diameters. Attached to and closely incorporated with the inner aspect of its lower half is an accessory kidney measuring 9 cm in length and about 3.5 cm in width. This distinctly demarcated mass would seem to represent the left kidney, and, even so, the two organs appear to be fused over a wide area.

Each has a separate hilum, pelvis, and ureter. On its posterior aspect the conjoined organ presents a very much flattened and altogether more uniform surface, the only sign of duplication being the entry of a large artery into the middle of the renal mass. The exact relation of the two organs to one another is accurately brought out by radiographic examination, after injection of both ureters with collargol solution (*Fig 13*). It is now seen

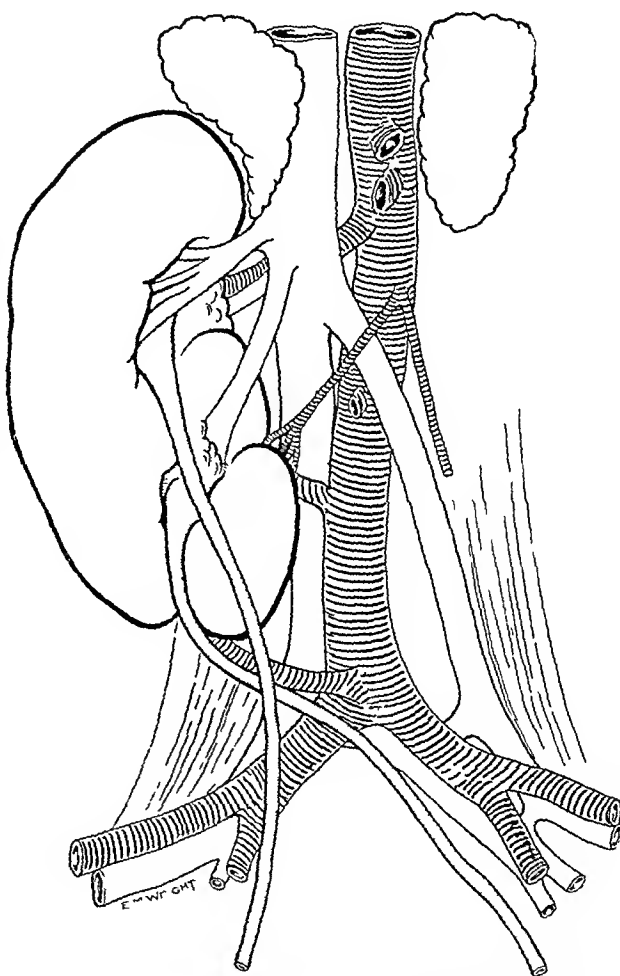


FIG 12.—Drawing of the specimen of unilateral fused kidney, with its vascular connections.

that the external appearances are deceptive, and that practically the whole of the lower half of the renal mass represents the left kidney. The complete independence of the pelvis and calices of each organ is also shown. The total weight of the fused organs in the fresh state is 252 gm, i.e., within normal limits for the kidneys taken together. The volume after formalin fixation is 202 c.c. The adrenals are normally situated.

Pelves and Ureters (Fig. 12)—The hilum of the normally situated kidney is directed forwards and inwards; that of the transposed organ almost directly forwards. That the upper half of the renal mass is the normally situated



FIG. 13.—Radiogram of the specimen after removal from the body. The two pelvis and their calices have been injected with collargol solution.

right kidney, and the lower half the transposed left kidney, is confirmed by the position and course of the ureters. The right ureter springs from the upper hilum roughly at the level of the 1st lumbar vertebra; this pelvis having one vein anterior to it and an artery and vein behind. The ureter runs downwards and slightly inwards over the fused organ, crosses the other ureter near the upper end of the right common iliac artery, and after a normal pelvic course opens into the right side of the bladder. Its length is about 28 cm.

The other ureter (the left) springs from the lower hilum, and at first runs almost directly downwards in a deep groove in the anterior surface of the kidney. It then passes downwards and inwards across the right psoas magnus muscle passes beneath the right

ureter, and crosses the middle line just below the bifurcation of the aorta. Thereafter it pursues a normal pelvic course, to enter the left side of the bladder in its proper position. Its length is about 26 cm.

Arteries (Fig. 12)—The right renal artery springs from the aorta immediately below the level of the superior mesenteric. It passes to the right behind the inferior vena cava and renal vein, and after a course of 6.5 cm enters the hilum of the right kidney proper behind the pelvis. A second, much smaller artery arises from the left side of the aorta a short distance below the first and passes downwards and to the right crossing in front of the

aorta and inferior vena cava After a course of some 7 cm it divides into four branches, which enter the inner border of the original left kidney A third artery of considerable size springs from the right side of the aorta 4.5 cm above the bifurcation, and runs upwards, backwards and outwards for a distance of about 8 cm, entering the posterior surface of the renal mass 6 cm above the lower pole and midway between the outer and inner borders A fourth fairly large artery springs from the front of the bifurcation of the aorta and runs upwards backwards, and to the right for a distance of 7 cm to enter the lower hilum behind the pelvis Thus, of these various arteries, it would appear that the first supplies the right kidney, the second third and fourth the left It is possible however that the third, a large vessel is distributed to both No injection experiments were made on the blood-vessels

Veins—As shown in *Fig 12*, the left external iliac vein, after a communication with the internal, passes up on the left of the aorta, which it crosses to join the inferior vena cava at the level of the 2nd lumbar vertebra There are three renal veins in all, one from the lower hilum and two from the upper All three join the inferior vena cava about the level of the 12th dorsal vertebra and just above the point of entrance of the left external iliac

Bladder—The offices of the ureters and plicæ uretericæ appear normal

REMARKS ON UNILATRAL FUSED KIDNEY

Gerard (1905)⁶ collected 14 cases of unilateral fused kidney from the literature We have found records of 13 others, making, with the one here reported, a total of 28

This list is the result of an extensive search through the literature, but is probably incomplete Papers by Hortolès (1882)¹⁰ and Thoreus (1870)¹⁸, for example, which we have not been able to obtain probably relate to this subject

Cases of unilateral fused kidney are all much alike, at least in their salient characteristics They differ from one another chiefly in respect of their vascular connections, and to some extent in the size and shape of the fused mass The amount of renal tissue present is usually rather less than that of two normal kidneys In the case reported by Kelly (1868),¹¹ however, it is stated that the fused organs weighed 93 oz No explanation of this extraordinary finding is given Some idea of the variations in shape is afforded by the drawings illustrating this paper (*Figs 12 and 14-19*)

In the great majority of cases the displaced organ lies below the normally situated one, its upper pole fused with the lower pole of the latter There would appear to be no rotation in the process of transposition, inasmuch as the hilum remains directed to the same side as would have been the case had the organ remained in its normal position This is well seen in Broesike's case (1884),² and less definitely in the present instance The true nature of the ectopia is clearly shown by the course of the ureters Invariably these arise from separate and clearly-defined pelves lying one above the other The ureter from the upper pelvis passes down to enter the same side of the bladder, that from the lower crosses the middle line and enters the bladder on the opposite side

The cases reported by Dickinson (1895)⁴ and by Kidd (1910)¹² are exceptional in that it is the upper half of the organ which is ectopic

Table III—LIST OF PUBLISHED CASES OF UNILATERAL FUSED KIDNEY

REPORTED BY	NO. OF CASES
Gerard, 1905 ⁶	14
Hunter, 1793, Horne, 1793 Sandifort 1793 Chassagnac (?) 1832 1840 Reed 1840 Stoicesko 1877, Stoequart 1880 Poulahon, 1890 Powell 1883 Tesson 1895, Chambrelent, 1896 Cathelin 1898 Finton 1901	
Hillel, 1864 ⁹	1
Kelly, 1868 ¹¹	1
Coupland, 1877 ³	1
Greenfield, 1877 ⁷	1
Brocsike, 1884 ²	1
Birmingham, 1890 ¹	1
Dickinson, 1895 ⁴	1
Sutherland and Edington, 1898 ¹⁶	2
" " 1900 ¹	1
Kidd, 1910 ¹²	1
Gerard and Fraser, 1911 ⁸	2
Stewart and Lodge	1
Total	28

Here the upper ureter crosses to the other side and enters the bladder in its proper place i.e. on the side from which the kidney is absent

In contradistinction to cases of congenital absence of one kidney, where multiple defects are common, unilateral fused kidney is rarely associated with other defects of the genito-urinary tract. Similarly, in all reported cases, the supra-renal glands have occupied practically their normal position

There is not sufficient evidence to show that fused kidney is more common on one side than the other. Gerard found that the fused organ occurred most frequently on the right side, but in the 14 cases which we have collected it was more common on the left, the ratio being 9 to 5

The vascular arrangements are anomalous. Usually three or four arteries pass to the fused organ, of which two supply the upper and two the lower half. One or both of the vessels for the upper half spring direct from the aorta, in or below the normal position. The vessels for the lower half are more irregular. They may arise from the lower part of the aorta, notably at the level of the bifurcation, or they may spring from the common



FIG 14
Coupland's case

half are more irregular. They may arise from the lower part of the aorta, notably at the level of the bifurcation, or they may spring from the common

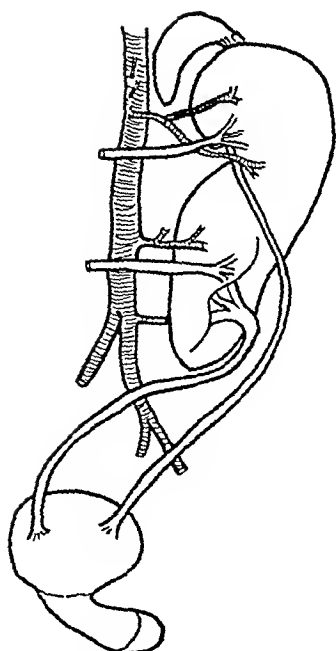


FIG 15—Broesike's case

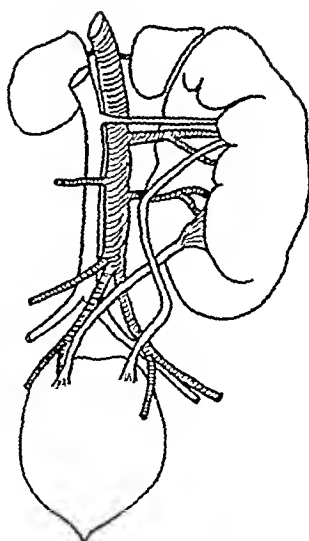


FIG 16—Sutherland and Edington's Case 1

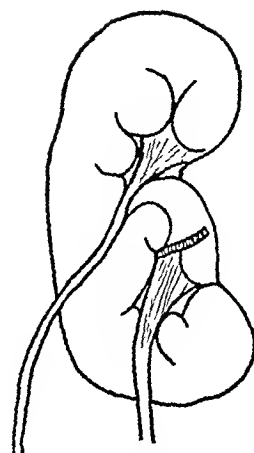


FIG 17
Sutherland and Edington's Case 2

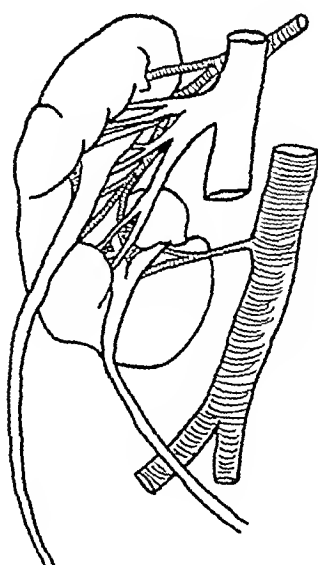


FIG 18
Sutherland and Edington's Case 3

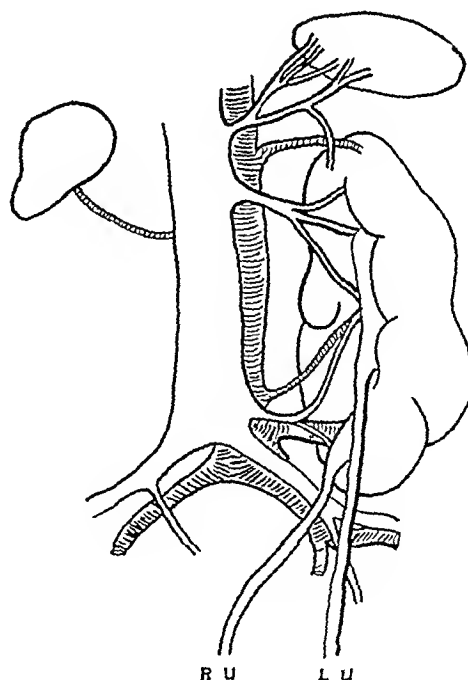


FIG 19—Gruner and Fraser's case

FIGS 14 TO 19—DRAWINGS FROM A NUMBER OF PUBLISHED CASES OF UNILATERAL FUSED KIDNEY

iliac artery of the opposite side (Birmingham 1890)¹ In Greenfield's (1877)⁷ case there was but one renal artery, which presently bifurcated to supply the two portions In Sutherland and Edington's (1900)¹⁷ third case there was one artery to each hilum

We desire to emphasize the clinical importance of cases of this kind It requires but little thought to appreciate the possible consequences should tuberculous calculous, or neoplastic disease of the normally situated organ call for surgical intervention Cystoscopic examination or even urethral catheterization would apparently reveal a normally functioning kidney on the side away from the lesion, and it might well be at a late stage of nephrectomy that the surgeon would discover he was dealing with a developmental abnormality of some kind Even then he might well assume the presence of nothing more unusual than a double ureter

Radiological examination in such a case would, of course be of the greatest possible service, since it would show that the normal renal shadow was lacking on one side, while the passage of opaque bougies or (preferably) pyelography, would completely establish the diagnosis

SUMMARY

The congenital renal abnormalities found in a consecutive series of 6500 post-mortem examinations are described The list includes 14 cases of horseshoe kidney 1 of unilateral fused kidney, 16 of congenital absence of one kidney, and 3 of 'pelvic' kidney The cases in which horseshoe kidney was found are compared with those in which one organ was congenitally absent, with respect to (a) the incidence of renal disease and (b) the age at death

The case of unilateral fused kidney is described in detail, and the published cases of this condition are collected and reviewed

We beg to express our indebtedness to Dr Leo A Rowden for the radiogram of the injected specimen of unilateral fused kidney, and to several writers on the subject of renal abnormalities for permission to copy their drawings

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METASTATIC TUMOURS OF BONE *

By CECIL A. JOLL, LONDON

THE object of this paper is to show that a knowledge of bone metastases, their mode of production, the types of neoplasms which give rise to them, and their special clinical manifestations, is essential not only in the study of pathology, but also in the practice of surgery

MODE OF ORIGIN

Secondary tumours in bones must of necessity arise in one of three ways (1) By direct extension of a tumour from tissues outside the bone into its substance—a method which I exclude, since it is incompatible with the definition of a metastasis as I understand it, (2) By extension through the blood-stream—either by malignant emboli conveyed through nutrient arteries or possibly by a retrograde route through the veins, or (3) By extension through lymphatic paths—a view which is compatible with either an embolic or a permeation conception of the origin of such metastases. With the latter theory the name of Sampson Handley¹ is prominently associated.

In order to prove whether metastasis in bone occurs through the lymph stream, a knowledge of the lymphatics of the periosteum, bone, and bone-marrow is imperative. It is not sufficient to show that the deep fascial lymphatics extend as far as the periosteum, they must be traced, if possible into the depths of the bone. Pinner,^{2, 3} in his recent investigations, has been able to confirm the statement of Roger and Josue⁴ that it is impossible to demonstrate lymphatics in any part of the bone-marrow. He used the technique of Dewey and Noyes,⁵ and found that the injection material could be forced through the compact bone, but never into the marrow proper. It was always arrested at the endosteum. This information must cast doubt at once on the opinion held by Handley that, in carcinoma of the breast, the metastases in bones are the result of centrifugal permeation of lymphatic vessels.

The only theory remaining to explain secondary deposits in the bones is that they reach the bone-marrow by way of the blood-stream. It was von Recklinghausen⁶ who first elaborated this conception—viz, that metastases in bone are the result of the arrest of malignant emboli in marrow capillaries.

In order to substantiate this claim it is necessary to demonstrate (1) That malignant emboli circulate in the blood-stream, (2) That such emboli are able to gain access to the systemic circulation, (3) That these emboli can obtain lodgement in the marrow blood-vessels.

* This paper is based on a Hunterian Lecture delivered by the writer at the Royal College of Surgeons in 1923.

It may be, as Nepveu (quoted by Roger Williams⁷) surmised that the malignant cell does not circulate as such, but in the form of minute cellular bodies, smaller than the fully developed cancer cell. This would make it easy to explain how it is possible for the metastasizing element to pass through the pulmonary capillaries. No confirmation of such minute cellules is forthcoming. On the other hand, Schmoil⁸ has been able to show that portions of chorionic villi are shed into the circulation in eclampsia and Veit⁹ later demonstrated that this may occur in normal pregnancy. By analogy we should expect that malignant cells also would pass into the circulation. Goldmann¹⁰ claims that this does occur and that the malignant cells reach the blood-stream by entering the lumina of smaller vessels especially the veins, via the vasa vasorum. It can be seen with the naked eye that tumours such as hypernephromata grow directly into the larger veins so that particles are readily washed away into the right heart. It is equally easy to understand that particles of growth may be conveyed along the thoracic duct and other large lymphatic vessels, and so directly into the main veins. Leaf¹¹ and others have demonstrated that there are numerous communications of a less obvious character between the lymphatic and blood-streams e.g. in the hæmolympth glands.

It is possible for malignant emboli to pass from the right side of the heart directly into the systemic circulation in those exceptional circumstances when some defect exists in the inter-auricular septum. In other cases the cells must either pass the pulmonary capillaries, or, when arrested in these capillaries, they must grow into the smaller radicles of the pulmonary veins, and again becoming free as emboli, so reach the left side of the heart. Schmidt¹² has demonstrated that such minute malignant emboli are in fact actually found in many cases in the pulmonary arterioles in the interior of thrombi, without any evidence of metastases in other parts of the body. These minute malignant pulmonary foci appear to remain latent, only exceptionally shedding emboli into the systemic circulation. Of these probably only a few survive to be arrested elsewhere in the body and produce metastases.

Von Recklinghausen⁶ believed that secondary growths in bone were due to such minute malignant cell masses being held up in the capillaries of the bone-marrow. He based this belief on the absence of lymphatics and the existence of a definite endothelial-lined space enclosing the malignant cells. Eibslöh¹³ carried this a step further by proving that in addition to the malignant cells, red blood-corpuscles could also be found enclosed in the same vessel. Pincy^{2, 3} contrasts the well-formed blood-vessels of the fatty marrow with the innumerable thin-walled capillaries of the red marrow, and sees in the latter a clear explanation why malignant emboli are arrested in the red marrow. His contention is that with the immense widening of the blood-stream which occurs as we pass from the yellow to the red marrow there is a corresponding diminution in the velocity of the stream, and that malignant cells tend to cling to the vessel wall and so come to rest, just as the leucocytes do under similar circumstances.

It follows from Pincy's claims that all bone metastases should be found in the red marrow, and therefore a knowledge of the distribution of this under varying conditions of health and age is necessary. Pincy³ has shown that

while in children the red marrow fills the marrow cavity, at about puberty this begins to be replaced by fatty marrow, but that while this change is completed in the distal bones of the limbs a considerable amount of red marrow persists in the upper ends of the humerus and femur. In the epiphyses, too, this transformation from red to fatty marrow occurs with puberty and adolescence though small foci of red marrow may persist throughout life. He was able to prove microscopically that throughout the fatty marrow minute foci of cellular red marrow could be found. A large quantity of cellular marrow can also be found in the ribs, vertebrae, sternum, pelvis, and skull bones and smaller amounts in the clavicle and scapula.

How, then, does the location of bone metastases accord with these findings as to the distribution of the red bone-marrow? The specimens illustrated in this paper provide a general confirmation of the contention that these two are interdependent, but there are certain exceptions. In a few cases secondary growths are found in parts of the bones normally deficient in red marrow. This may be explained by the presence of minute foci of cellular marrow throughout the shafts and epiphyses. It may well be, too, that as a result of the severe constitutional disturbance set up by some forms of malignant disease an extension of the cellular bone-marrow occurs in order to provide for new blood formation. With this increase in the volume of the red marrow there will be opportunity for secondary deposits to occupy anomalous sites. If we accept Piney's claim that all bone metastases occur in the cellular red marrow we can then account for the frequency of such deposits in the ribs, vertebrae, skull, sternum, and the upper ends of the humerus and femur. We must explain the exceptional sites of secondary deposits as the result of macroscopic or microscopic irregularities of the distribution of the red marrow. Professor Handley regards the relative freedom of the distal limb-bones from metastases as evidence in favour of the lymphatic permeation theory contending that the nearer the bone to the primary growth (in this case the breast), the greater the tendency for secondary growths to occur therein. Piney, on the other hand, explains the freedom of the distal limb-bones as the natural outcome of the absence of red marrow from these bones. Systematic examination of the bones in various malignant growths reveals a surprisingly large number of unsuspected metastases, usually very small in size, but all of them situated in the red marrow. Von Recklinghausen⁶ believed that when surrounding tissues were also involved, this was due to the central growth having emerged through issuing veins of the bone, and that there was no evidence of the reverse process. Eibslöh and Piney both confirm this opinion.

It appears to me that the evidence is preponderatingly in favour of the claim that bone metastases are blood borne, and that they are due to the lodgement of malignant emboli in the cellular marrow. If we accept the lymphatic permeation theory of the origin of these secondary growths, how can we explain a femoral deposit from carcinoma of the tongue, a metastasis in the humerus from carcinoma of the rectum, a secondary growth in the radius from a primary in the bladder—unless, indeed, we regard these all as exceptional, or alternatively consider that the breast metastasizes differently from all other tumours?

PRIMARY TUMOURS WHICH GIVE RISE TO BONE METASTASES

In order to verify if possible, the current statements concerning the relative tendencies of neoplasms to produce secondary growths in bones, I have searched the records of the autopsies at the Cancer Hospital from 1888 to October, 1922. It is obvious that the figures which were obtained must suffer from the legitimate criticism that post-mortem examinations unless specially directed to the examination of the skeleton for metastases, will often fail to reveal anything but the gross and obvious deposits. Only when the bones are systematically removed and sections made with a saw will the smaller secondary growths be discovered so that the figures in *Table I* can only refer to those more obvious masses easily detected by palpation, by the presence of a spontaneous fracture, or by gross external deformity.

Table I—METASTASES IN BONES FOUND IN 1144 AUTOPSIES FOR MALIGNANT DISEASE, MANY OF THEM ADVANCED CASES

PRIMARY GROWTH	NO OF CASES WITH METASTASES
Carcinoma of breast	34
" , uterus	2
" , oesophagus	2
" , thyroid	2
" , gall-bladder	1
" , tongue	1
" , prostate	1
" , palate	1
" , adrenal	1
" , kidney	1
Sarcoma of tonsil	1
" , tibia	1
" , testis	1
" , back	1
" , chest wall	1
" , neck	1
Doubtful	1
Total	53

This list, while confirming the great frequency of bone metastases in breast carcinoma does not suggest that the thyroid and prostate are specially prone to such metastases, unless we bear in mind how few of the latter are included among the 1144 cases which came to autopsy. The table does bring out the interesting point that squamous carcinoma (tongue oesophagus soft palate) has a tendency to produce secondary deposits in bone which is not, I believe, generally appreciated.

I have tried to supply the deficiencies in this table of primary tumours by an examination of the bone tumours in the Museum of the Royal College of Surgeons and the museums of the hospitals in London. In addition to those given in the table I found the following melanotic sarcoma sarcoma of the nasopharynx papilliferous carcinoma of the bladder, hypernephroma,

carcinoma of the renal pelvis, carcinoma of the liver, carcinoma of the rectum, squamous carcinoma of the penis, primary carcinoma of the lung, and carcinoma of the cervix. In confirmation of the statement made above as to the association of squamous carcinoma and bone metastases, there were found preserved in the museums six such specimens, four from the oesophagus and one each from the tongue and penis.

A search of the literature revealed a few other primary tumours not yet mentioned which produce secondary deposits in bone—notably carcinoma of the stomach. The late Sir Norman Moore¹⁴ found one spinal metastasis in 29 autopsies. Colwell,¹⁵ Kuipjuweit,¹⁶ Goetsch,¹⁷ Zade,¹⁸ Perry and Shaw,¹⁹ and Harrington and Kennedy²⁰ have also recorded such cases, some of them with numerous deposits in bones. Bone metastases have also been noted in sarcoma of the breast by Gross²¹ and by Vichow²², though these statements are open to the objection that malignant tumours of the breast were formerly far more commonly diagnosed as sarcoma than is the case to-day. Glioma of the eye, in addition to the relatively commoner melanotic tumours of that organ, may produce metastases in bone, and Knapp²³ has described one such case in the skull. In deciduoma malignum Roger Williams found 2 examples of bone metastases in 50 cases.

SITES OF ELECTION OF BONE METASTASES

Table II indicates the extent to which the several bones were affected in the 88 metastases found in 53 cases.

Table II—LOCATION OF BONE METASTASES IN 53 CASES

BONE	NUMBER	PER CENT
Vertebrae	19	21.6
Ribs	18	20.4
Sternum	13	14.7
Femur	13	14.7
Skull	9	10.2
Humerus	7	7.9
Pelvis	4	4.5
Tibia	2	2.2
Mandible	1	1.1
Scapula	1	1.1
Clavicle	1	1.1
Total	88	

When this list is reviewed in the light of the literature it appears that there is some difference of opinion as to the bones most commonly involved. Roger Williams,⁷ in a collection of reports from several sources, states that in 893 post-mortems in cancer of the breast there were 26.5 per cent with secondary growths in bones, and that the commonest bones involved were the skull (24 per cent) and the vertebrae (19.1 per cent), while Ewing²⁴ places the sternum, ribs, and femur before the skull and vertebrae in order of

frequency Kaufmann (quoted by Ewing) found over 50 per cent with metastases in bones in a series of 63 autopsies, 14 per cent of them showing definite osteoplastic changes

In 238 cases of malignant disease of the thyroid of all types, Ehrhardt²⁵ found 66 with secondary deposits in bones, a much lower proportion than Kaufmann found for the breast. He places the relative frequency of such deposits in the following order—skull, sternum, spine, ribs, humerus, femur, pelvis. Kaufmann²⁶ states that in 70 per cent of prostatic carcinomata metastases are found in the bones—a higher percentage than in any other form of malignant disease. Osteoplastic changes he noted in many and in some it was of a most extensive character even when the primary growth was so small as to be overlooked until the autopsy.

Adler,²⁷ in 374 cases of primary malignant disease of the lungs and bronchi, found 57 examples of deposits in the bones (some of them of an extensive nature), with a special tendency to involvement of the ribs, spine, skull, and sternum. The incidence was approximately equal for both sarcoma and carcinoma.

Scudder²⁸ has collected 17 cases of deposits in bones occurring in hypernephroma. Albrecht²⁹ mentions 2 of Hochenegg's cases in which the only metastases discoverable at the autopsy were in the bones. Hutchison³⁰ described a series of suprarenal sarcomata in children in which the initial sign was a tumour of the skull, and found that while the ribs, sternum, and vertebrae were also occasionally involved, the long bones appeared to escape. He admits that some of these might be examples of hypernephromata. Ewing²⁴ considers that in fully verified adrenal carcinoma, as distinct from hypernephroma, secondary growths in bone are rare, and Hartmann and Lecene³¹ found only 1 in 48 cases, though Winkler³² claims 3 in 10.

There seems to be a tendency for periosteal sarcoma of the femur and tibia to produce deposits in other bones, as Butlin and Colby's³³ figures indicate, and as Greenough's³⁴ report confirms. That rare tumour of bone, the endosteal endothelioma, has a predilection to metastasize in the flat bones, according to Gideon Wells,³⁵ though, as Symmers and Vance³⁵ point out, it may be difficult to distinguish such secondary tumours from multiple primary growths.

The only remaining viscus malignant disease of which has a tendency to produce deposits in the bones is the testis. In view of the obscurity of the classification of such tumours it is not possible to state the relationship between the exact type of malignant tumour and the tendency to metastases in bones, but of 13 cases of sarcoma of the testis Butlin³⁷ found 3 with secondary growths in bones.

Nearly all these figures are open to the criticism which has already been mentioned—viz, that in most of these reports a systematic examination of the whole skeleton by sectioning the bones has not been carried out but only the bones bearing obvious signs of disease have been removed for study. The few observers who have adopted the detailed method of investigation such as I have outlined have found that deposits are far more numerous than would be suspected by mere external examination and that bones generally regarded as immune from metastases may contain minute secondary deposits in the marrow. This is an added reason why the argument for a lymphatic

origin of deposits in bone, based on the alleged immunity of the distal limb-bones, must be rejected

It is difficult to account for the single, slowly growing metastasis which sometimes is found in bones such as the clavicle or scapula, without taking into consideration the traumatic factor. Examples of this kind of deposit are generally associated with obscure primary neoplasms, e.g., of the kidney or thyroid, and a history of trauma is sufficiently common to be noteworthy. Can it be that circulating malignant emboli are able to obtain a footing when the bone is damaged locally by injury? It would help to explain the deposits in the skull in Hutchinson's³⁰ series of adrenal growths in children.

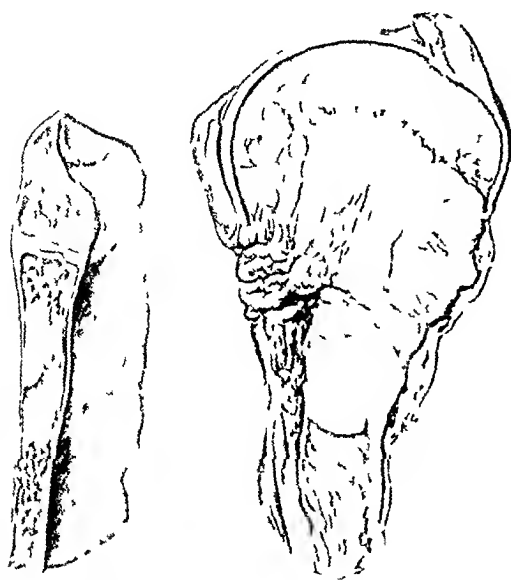


FIG 20

FIG 21

FIGS 20-21—Secondary growths in sternum (1) and humerus (2) from case of carcinoma of breast. In (1) the absence of external swelling is noticeable. In (2) there is a spontaneous fracture. R.C.S. Museum (Sir Astley Cooper's Collection) 2081.1 and 2081.2

ILLUSTRATIVE CASES

We will now pass on to a series of cases illustrating the more

characteristic features of metastatic tumours of bones based mainly on specimens from the Museum of the Royal College of Surgeons and the hospital museums in London and arranged under headings indicating the primary growth.

Breast—Figs 20 and 21 are from Sir Astley Cooper's Collection, and show metastatic masses in the sternum and humerus. The former exhibits little external deformity, and could easily be overlooked in the usual routine post-mortem examination. The humeral deposit higher up than is the case with

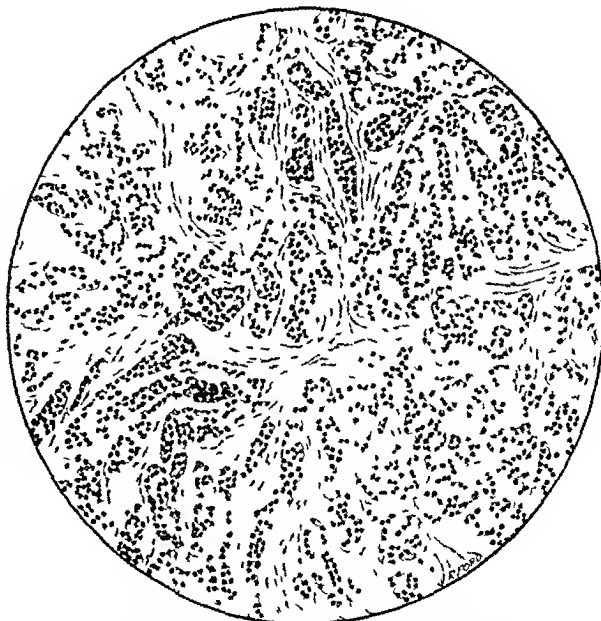


FIG 22—Section from same case as shown in Figs 20 and 21. It has the structure of a rather cellular scirrhous carcinoma of the breast.

many such is situated where the red marrow of the bone is most abundant. The head is extensively infiltrated, and there is a pathological fracture. The microscopic section (*Fig 22*), taken from the sternal deposit, reveals the characteristic structure of a scirrhous carcinoma of the breast. The next specimen (*Fig 23*), from the R C S Museum illustrates the osteoplastic type of growth, but in spite of this new bone formation there are two fractures,

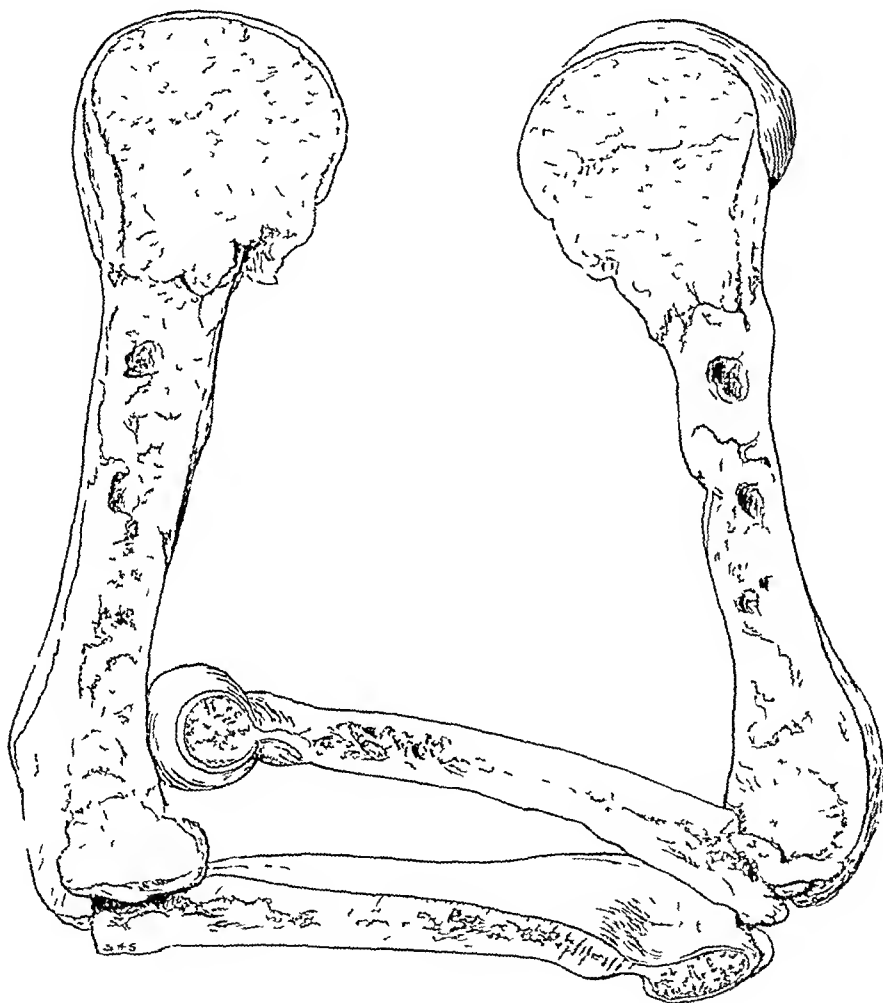


FIG 23—Humerus showing extensive infiltration with secondary deposit from carcinoma of breast. Much new bone is formed, and there are two spontaneous fractures. R C S Museum, 20821

the lower one nearly in the centre of the shaft. There is a specimen in St Thomas's Hospital Museum (No 215) of a secondary deposit in the femur, with very little evidence externally of growth, but the whole shaft is infiltrated and the bone has bent into an S-shaped curve. A fracture can be seen in this specimen which has united—not an unusual occurrence in bones with secondary growths of mammary origin.

Thyroid—The special facility with which malignant disease of the thyroid gland metastasizes in bones has long been recognized. Sir Henry Morris³⁸ described one of the early cases, associated with a pulsating tumour of the skull. The specimen is preserved in the Museum of the Middlesex Hospital (C 168). The tumour followed trauma, and was associated with an apparently simple bronchoecle. Warrington Howard,³⁹ soon after described a case with deposits in the skull, scapula, pelvis, and cervical vertebrae, and of these some pulsated and others did not indicating that pulsation has no diagnostic significance.

Kanoky⁴⁰ states that there is no obvious clinical enlargement of the thyroid in a quarter of the cases of thyroid metastases in bone. In another

Table III—BONE METASTASES ASSOCIATED

NO	AUTHOR	SEX	AGE	SITE OF METASTASIS	TIME PRIOR
1	Cohnheim ⁴¹	F	35	Right femur, lumbar vertebrae	—
2	Morris, H ³⁸	F	40	Skull, clavicle, both femora	2 years
3	Howard, W ³⁹	F	59	Skull, pelvis, cervical vertebrae	7 months
4	Coats, J ⁴²	F	16	Skull	1½ years
5	Litten ⁴³	—	—	Vertebrae, ribs, pelvis	—
6	Fenre ⁴⁴	F	68	Left parietal	9 months
7	Gussenbauer ⁴⁵	F	—	10th and 11th dorsal vertebrae	1½ years
8	Ewald, C ⁴⁶	F	45	Scapula	Appeared 1½ years after removal of innocent goitre
9	„ „	F	26	Malar bone	7 years
10	Hreckel ⁴⁷	F	48	Lower jaw	3 months
11	Kriske ⁴⁸	F	53	Sternum	4–6 weeks
12	„	F	53	Frontal bone	—
13	Von Eiselsberg ⁴⁹	M	38	Parietal bone	4 years
14	„ „	M	33	Base of skull	—
15	Middeldorpf ⁵⁰	F	56	Skull, vertebrae, sternum, pelvis, humerus, femur	—
16	Hoffman, K von ⁵¹	F	69	Right humerus	—
17	Jaeger, R ⁵²	F	69	Mid dorsal and lumbar vertebrae	1½ years
18	Muzio ⁵³	F	43	Pelvis—followed injury	—
19	Goebel ⁵⁴	F	51	Right femur	2½ years

group the gland though enlarged, may have undergone no change for thirty years. In yet another group the thyroid may have been operated on for a benign tumour, years before the deposit in the bone appeared. In a majority of cases the metastasis is slow in its growth and may be the sole metastasis present in the body. This has been confirmed by careful post-mortem examinations. A knowledge of this fact must modify our attitude in treating tumours of bone of thyroid origin.

It was Cohnheim⁴¹ who first claimed that metastasis could occur from a benign enlargement of the thyroid gland, though both von Recklinghausen⁴² and Wölfler⁴³ denied the benign nature of the thyroid in Cohnheim's case. I have arranged in *Table III* the whole series of cases, of which I have been able

WITH A NORMAL THYROID OR BENIGN GOITRE

SYMPTOMS CAUSED BY METASTASIS	MICROSCOPIC STRUCTURE OF METASTASIS	CONDITION OF THYROID GLAND	REMARKS
—	Innocent goitre	General enlargement	Autopsy revealed nodule in thyroid penetrating a vein
pulsating tumour (l), head ache	Normal thyroid gland	General swelling	Lived 6 years. Specimen No C168, the Middlesex Hospital Museum
pulsating tumour (l), pulsating vis) itting, painful	"Ordinary broncho-ecele"	General swelling present 21 years	Lived 6 weeks. Numerous deposits in viscera
—	Innocent goitre	Calcareous change in simple goitre	Goitre present 16 years
—	—	Adenomatous colloid goitre	—
and swelling owing a blow (3 itlis)	Typical colloid goitre	Small colloid goitre	Reappearance in 10 months
and purpura	Adenoma of thyroid	Large left-sided goitre	Goitre not removed
ling	Adenocarcinoma	Colloid goitre	Microscopically, goitre innocent
"	Fœtal thyroid—with "slight malignant tendency"	Colloid goitre	Noticed years before goitre
—	Adenoma	Large colloid goitre	Goitre not removed, patient alive 3½ years, no recurrence
—	Adenoma	Ordinary colloid goitre	Goitre not removed, alive 3 years, no recurrence
and painless swelling	Normal thyroid	" " "	Still alive after 8 years
—	Adenoma	Large simple goitre	Goitre for 18 years, recurrence 4 years, alive after 8 years
—	Adenocarcinoma of thyroid	Benign goitre	At autopsy, adenomatous nodules in thyroid
—	Adenoma—typical	Small—movable—no sign of malignancy	No change in thyroid throughout
—	Colloid goitre	Simple goitre	—
and swelling 6 months after injury	Normal thyroid—some areas fœtal thyroid	" "	Goitre present 10 years
ling	Colloid goitre	Benign goitre	" "
at mucous fracture	Benign goitre	Moderate sized goitre—tough	Goitre present 30 years (stationary)

Continued on next page

Table III —BONE METASTASES ASSOCIATED

NO	AUTHOR	SEX	AGE	SITE OF METASTASIS	TIME PRESENT
20	Honsell, B ⁹	F	20	Frontal bone	—
21	Oderfeld, H, and Steinhaus, J ²⁰	F	58	„ „	—
22	Gierke, E ⁴⁵	M	37	Ribs and dorsal vertebrae	4 years
23	Hollis ⁶¹	M	45	Skull and dorsal vertebrae	—
24	Graig, K S de ⁶²	F	52	Lower dorsal vertebrae	—
25	Gierke, E ⁴⁵	M	46	Dorsal and lumbar spine	—
26	Patel ⁸³	F	65	Orbit	—
27	Riedel	F	40	Mandible	7 years
28	Emmerich, E	M	68	Sternum, spine, pelvis	—
29	Halbron ⁶⁴	F	68	Sternum	—
30	Dereum, F X ⁶⁵	F	56	Ribs, cervical vertebrae	5 years, 1 ve after operation got
31	Halperinc ⁶⁶	M	54	Clavicle	20 years
32	Beilby, G E ⁶	M	63	Upper jaw	—
33	Kocher, T ⁶⁸	M	60	Occipital bone	Few months
34	Estor, E, and Massaburam, G ⁶⁸	F	40	Left clavicle	5-6 months
35	Gube and Leguen ⁹⁰	F	51	Clavicle	—
36	Jaboulay ⁶⁹	M	77	Humerus	—
37	„	F	60	Clavicle	—
38	Alamartine, H, and Bonne [†] , P ⁹¹	F	23	Humerus	—
39	Regensburger, F ⁴⁶	F	55	Humerus	2 years
40	Elmslie, R C ⁶³	F	61	Radius	3 months
41	Radley and Duggan ⁴⁸	M	46	Clavicle	6 months
42	Kanok, J P ⁴⁰	F	40	Skull	6 years befo death
43	Knapp, A [—]	F	66	Orbit, scapula, ribs	1 week
44	Joll, C A	F	47	Left clavicle	6 months

A. NORMAL THYROID OR BENIGN GOITRE—*continued*

CAUSED BY METASTASES	MICROSCOPIC STRUCTURE OF METASTASES	CONDITION OF THYROID GLAND	REMARKS
pulsating tumour	Colloid goitre	Simple goitre	7 years before, operation cystic tumour (skull) 2½ years before, operation benign goitre Later right lobe enlarged
—	Normal thyroid — as also were all deposits	No goitre	—
—	Colloid goitre	No goitre	Small adenoma found at P M
—	Thyroid tumour with epithelial proliferation	No goitre	—
—	Innocent goitre	Colloid goitre	—
—	Colloid goitre	Small goitre	No clinical evidence of malignancy
growing tumour	Mainly normal thyroid — parts malignant	General enlargement	No clinical evidence of malignancy, goitre 30 years, no increase
—	Normal thyroid	No enlargement throughout	Recurrence after 10 years
—	" "	—	—
growing tumour	Thyroid tissue with malignant epithelial change	Small pulsating goitre	Goitre—section—benign colloid type
and paraplegia	—	Simple bilateral goitre	Goitre removed 6 years before
—	Thyroid tissue	General enlargement—no evidence of malignancy	—
—	Thyroid adenoma	No trace of goitre	—
—	—	Innocent goitre	Goitre removed months before
—	Thyroid tissue	" "	No recurrence 1½ years
and pulsation	" "	Thyroid normal	Well 1½ years later
growing tumour	" "	Small goitre—no symptoms	—
—	" "	Goitre 7 years—rapid growth 14 months	Sections of goitre—benign
growing tumour	" "	Benign goitre	Death from multiple bone deposits
—	Typical thyroid tissue	Slight general enlargement	Arm disarticulated
—	Follicular adenoma	Hard fixed swelling right lobe (several years)	X-ray examination whole skeleton, revealed no other deposits Well 10 to 12 months later
and pulsation	Secondary adenoma	Normal in all respects	Small thyroid tumour shelled out 2 years before
and cerebral compression	Normal thyroid tissue	Intrathoracic goitre right lobe	Goitre 20 years before death Partly removed 9 years after first noticed No change later in goitre
—	Thyroid adenoma	No palpable goitre	2 years later calcified mass in left lobe of thyroid
—	Normal thyroid tissue	Firm movable tumour right lobe	Well 1 year later

to obtain records, in which one or more deposits in bone were found associated with what was considered either as a normal thyroid gland or a benign form of tumour or enlargement. That some cases of this character have occurred I think admits of no doubt since the microscopic structure both of the thyroid gland and of the deposit in bone have been fully investigated, and correlated with the subsequent history of the patient. It is otherwise with the majority of the cases in the list, for either the primary tumour had not been removed or the description of its nature leaves a doubt as to its benignity. In a few of the examples cited in the table the metastatic deposits were clearly malignant in type, even though the primary tumour is described as benign in structure. It seems probable that most of these anomalies can be explained, when the difficulty of drawing the line between innocent and malignant tumours of the thyroid—a difficulty mentioned by nearly all writers on this subject—is appreciated.

In one of von Eiselsberg's cases,⁴⁴ although a secondary deposit in the skull was, after removal, found to have the structure of a benign adenoma, it recurred. He points out, in this connection, that in some cases metastases of bone of thyroid origin have a more innocent microscopic appearance than metastases in such viscera as the lungs. Another of von Eiselsberg's cases illustrated the capacity of a secondary deposit to carry on the function of the thyroid gland for after removal of such a metastatic mass the patient relapsed into a condition of cachexia strumipriva.

Gierke⁴⁵ was able to carry the proof of the thyroid nature of such deposits a step further by the discovery of iodine in them. This author considers such deposits in the bones as essentially malignant, in spite of their apparently benign structure even when the thyroid is itself normal.

Regensburg⁴⁶ describes a case in which the arm was removed for what was thought to be a primary sarcoma, yet on removal this proved to be a thyroid metastasis.

A case somewhat similar, the specimen of which is shown in *Fig. 24*, was presented by the President of the Royal College of Surgeons Sir Anthony Bowlby who has kindly provided me with details. This drawing is



FIG. 24.—Vertical section of humerus showing secondary thyroid tumour. St. Bartholomew's Hospital Museum No. 514.

Anthony Bowlby who has kindly provided me with details. This drawing is

taken from the specimen in St Bartholomew's Hospital Museum (No 514). The patient, a woman of 53, was said to have had exophthalmos at 28 years of age, but no true evidence that she had Graves' disease is forthcoming. At 38 years the thyroid was examined and found to be enlarged and indurated. It grew no bigger, but became so hard as to appear to be calcified. The thyroid did not change up to the time the arm was removed for a tumour of the humerus associated with pain and disability. The patient lived nearly six years after, but there was evidence in the interval of an intrathoracic extension of the thyroid gland which was only partly controlled by X-ray treatment. The patient eventually developed a spinal deposit, with spontaneous fracture and paraplegia. The section from the tumour (*Fig 25*) is clearly of thyroid

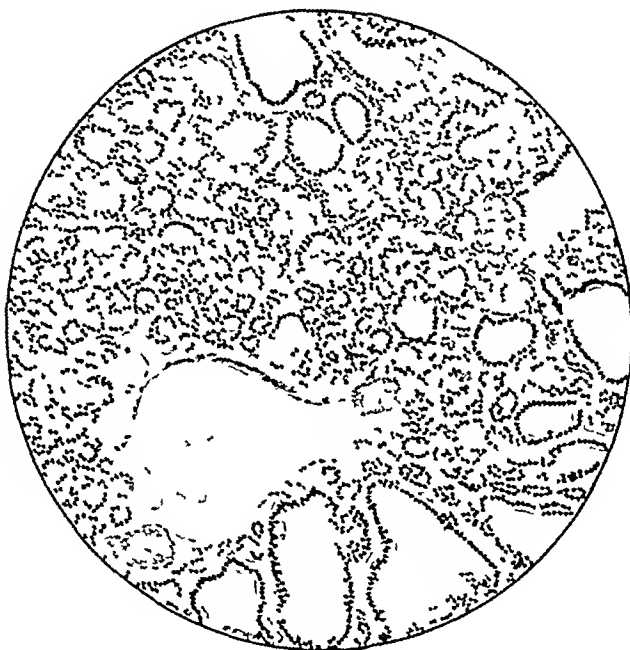


FIG. 25.—Section from specimen shown in *Fig 24*. Well formed vesicles, some containing colloid are visible.

origin with vesicles of irregular size and shape with a large mass of colloid in one of them and traces of this material in several others. This case is not included in *Table III* owing to the fact that the subsequent history of the patient suggests a slowly progressive malignant tumour of the thyroid. The great interest lies in the close simulation of a primary tumour of the humerus associated with an apparently calcified goitre.

Goebel¹⁷ was able up to 1898 to collect 11 cases of metastases of thyroid structure in bones which were treated radically on the assumption that they were primary tumours and he reported 4 others treated palliatively for various reasons.

In *Table III* it is clear that only a limited number of the cases are reported with that fullness which carries conviction and in several the thyroid gland

was not operated on at all. Some pathologists maintain that nothing short of a complete survey of the whole thyroid by serial sections could prove the absence of a minute malignant growth, but even this extreme claim cannot prevail against the fact that after the removal of such thyroid metastases the patient has remained well for years and the thyroid has not altered its characters.

My own case is too recent to dogmatize on. The patient, a woman, age 47, was first seen at the Miller General Hospital on Sept. 8, 1921, with a history of pain and weakness in the left arm, and a tumour in the sternal end of the left clavicle. At that time the tumour was firm, but when seen again on Oct. 26 it had increased considerably and there were soft areas in it. A skiagram showed a central tumour with much absorption of bone, and the diagnosis of a myeloma was made.

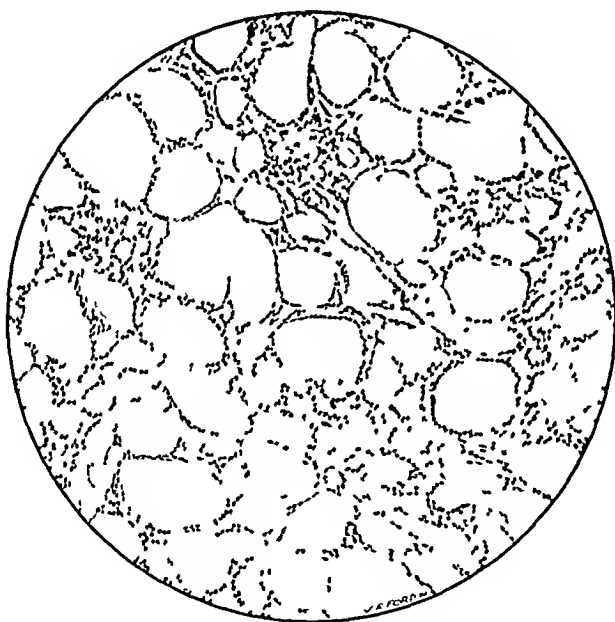


FIG. 26.—Section from tumour of clavicle shown in Fig. 27. The regularity of the vesicles which nearly all contain colloid clearly indicates an innocent type of tumour.

I operated on Oct. 27, disarticulating the sternal end of the clavicle and freeing it as far out as its middle point, where it was divided and removed with some fibres of the sternomastoid, which it was involving. There was no special difficulty in the operation, and little blood was lost. The wound was drained for a day and healed per primam. The functional result was good, the patient being able to use the arm freely within a month. The sections of the growth were at first thought by Dr. Arthur Davies, Pathologist to the Miller General Hospital, to show a columnar adeno-carcinoma, but on careful re-examination Dr. Davies came to the conclusion that the tumour was of thyroid origin. Sections were cut from five blocks from the whole length of the mass. They all show a similar appearance, which, as may be

seen from the section (*Fig 26*) is that of an innocent goitre, the vesicles are of regular shape, and most of them contain colloid. Only after the discovery of the thyroid structure of the clavicular tumour was attention paid to the thyroid gland. It was found to contain a small, firm, but quite movable tumour of the right lobe having all the physical features of an innocent encapsulated tumour. I was not able to persuade the patient to allow me to remove this. A year after the operation there is no change whatever in the size or other character of the thyroid tumour, nor is there evidence of recurrence of the growth. The specimen (*Fig 27*) has been split longitudinally, and the pale tumour can be seen expanding the bone.

It may be objected in this case that the thyroid tumour may be a malignant adenoma, a growth which resembles closely an innocent thyroid tumour, and is revealed in its true colours only by recurring *in situ* after apparently complete removal. We do not, however, expect to meet with metastases at all in malignant adenoma, but rather do we expect a local recurrence causing death from the involvement of the trachea etc. It must also be very rare for a malignant adenoma to remain stationary for a year.



FIG. 27.—Author's case. The sternal end of the clavicle is expanded and absorbed by the pale tumour substance.

Radley and Duggan⁴⁸ describe a case of somewhat similar type, operated on by Sir William Thorburn, in which a benign neoplasm had been removed two years before the appearance of the clavicular tumour, and had not recurred at the time of operation on the latter. The structure of the mass was that of a secondary tumour of the thyroid. These authors were so convinced of the integrity of the thyroid itself, that they suggest that the clavicular tumour must be due to a thyroid inclusion in the clavicle of congenital origin. I have submitted this suggestion to Dr E. Fawcett, Professor of Anatomy at the University of Bristol, who writes: "This inclusion is very unlikely, as the thyroid and the clavicle are developed from different strata and the thyroid is deep to the depressor muscles of the hyoid."

The relation between the thyroid gland and metastases in bones may therefore be—

- 1 The thyroid gland may be quite normal in every way and the metastasis may have either the structure of normal thyroid tissue of an innocent thyroid tumour or of a tumour exhibiting any degree of malignancy.

- 2 The thyroid gland may be the seat of an innocent diffuse goitre or of an encapsulated innocent tumour and the bone tumour may have a similar structure. On the other hand the metastatic tumour may show various grades of malignancy.

- 3 The tumour of the thyroid may be of any grade of malignancy yet the metastatic growths in bones may have the structure of an innocent goitre.

Prostate—These growths have perhaps the greatest tendency of all the primary tumours to produce secondary deposits in bones. In the one example of this in the Cancer Hospital records, the bones affected were the pelvis, ribs, scapula, skull, humerus, and clavicle. A remarkable amount of new bone formation may occur in such deposits sometimes amounting to a diffuse formation of bone involving the whole shaft obliterating the marrow cavity, and even projecting from the surface in an irregular series of osteophytes, tubercles and stalactitiform outgrowths. The new bone may be almost spongy in consistence, or on the other hand extremely dense. Severe secondary anaemia, even simulating pernicious anaemia may occur if the bone-marrow is extensively replaced by this new bone.

A good specimen of this type of prostatic metastasis involving the femur is shown in *Fig 28*. It is from the Collection in the R C S Museum (presented by Mr Hey Groves), the patient age 69, during life having had pain and difficulty in micturition, and pain in the upper end of the right femur associated with a malignant growth of the prostate. The upper end of the femur has been invaded by an ossifying neoplasm, which completely destroyed the normal architecture, and produced spontaneous fracture and *coxa vara*. There is also an irregular mass of new subperiosteal bone visible on the surface. The section from the primary tumour (*Fig 29*) is manifestly an infiltrating spheroidal carcinoma, and the secondary deposit (*Fig 30*) shows a similar structure, with much new bone surrounding the masses of carcinoma cells.

Von Recklinghausen⁶ drew attention to the resemblance between this ossifying type of secondary prostatic carcinoma and diffuse chronic inflammatory lesions, and he ascribes to the carcinoma cells themselves the capacity to produce this new bone.

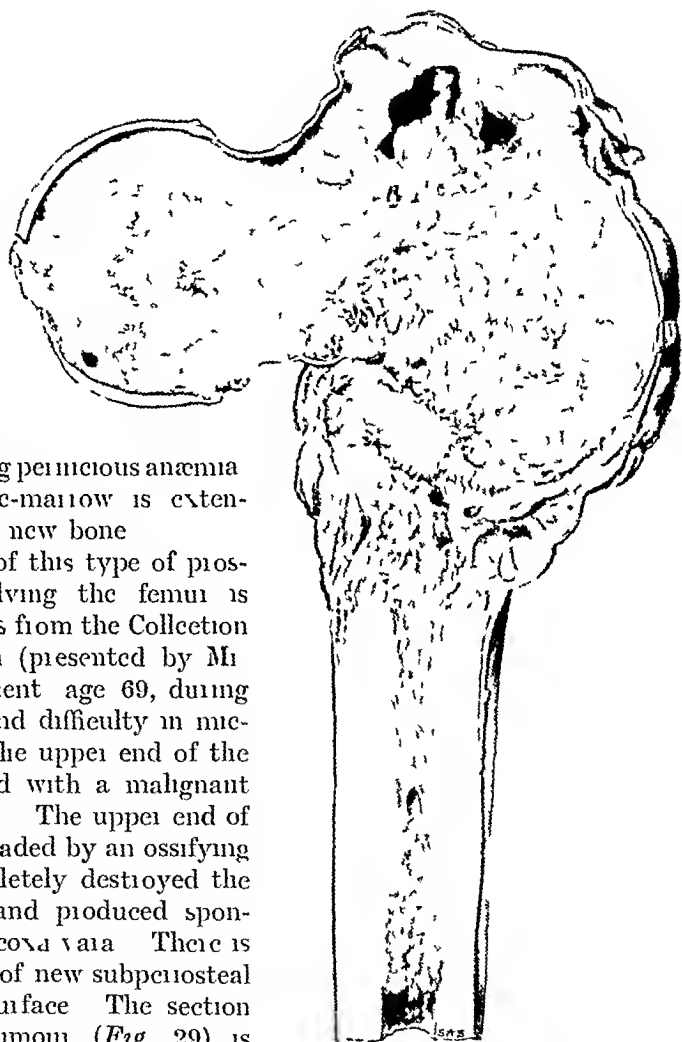


FIG 28—Secondary prostatic carcinoma in upper end of femur. Head and neck extensively infiltrated. Spontaneous fracture. Much new bone formation. R C S Collection (unmounted)

The primary growth in the prostate may occasionally be so small as to be overlooked during life. A specimen in the R C S Museum (No 17411)

FIG 29—Section from primary tumour of prostate. The spheroidal carcinoma can be seen invading the bladder muscle fibres. From the case shown in Fig 28



shows a malignant growth of the prostate which has not caused any enlargement of the gland and gave rise to no symptoms yet there is a metastatic



FIG 30—Section from the secondary deposit shown in Fig 28. Masses of spheroidal cells can be seen in the cavities between the new bone trabeculae.

deposit in the ribs the microscopic section of which proves it to be a spheroidal carcinoma similar to that in the prostate

Another series of specimens in the R C S Museum, from Silcock's case,⁴⁹ illustrates that in the same case there may be varying degrees of osteoplastic change, for while in the deposit in the skull (*Fig 31*) it is well marked, in the femoral metastasis there is much less new bone, and the ununited pathological fracture shows not a sign of callus. A section clearly exhibits the nature of the primary growth.

Sasse,⁵⁰ in discussing the nature of the osteoplastic changes in prostatic metastases, points out that the first deposits are found in the spongy osseous tissue (in other words where the cellular marrow is found) and adds that this



FIG. 31.—Secondary prostatic carcinoma in skull. There is much new bone formation on both inner and outer surface. The original outline of the skull is clearly preserved. R C S Museum 20911.

is only explicable on the theory of conveyance through the blood-stream. Axhausen⁵¹ believes that the osteoplastic property lies in the connective-tissue stroma of the cancerous deposit, but that the stimulus to such ossification proceeds from the carcinoma cell itself. He also emphasizes that osteoclasia goes on side by side with osteoplastic changes, hence spontaneous fractures are quite compatible with a high degree of osteoplastic change in the bone. Erbsloh⁵² agrees with von Recklinghausen's opinions on the whole, as to the source of the new bone, but considers that the connective tissue may take a share in the formation of the bony deposits.

Braun⁵³ in a series of papers, describes a form of anæmia closely resembling

pernicious anæmia, associated with the diffuse form of osteoplastic carcinoma of prostatic origin. In the example he cites, the primary growth was too small to be recognized clinically, so that great difficulty arose in distinguishing the tumour of the bone from a primary neoplasm. He adds that the fearful pain in the bones should be helpful in this distinction.

Other Parts of the Genito-urinary System—The whole of the urinary tract seems to share with the prostate in the tendency to metastases in bones.

The Bladder is here represented by a specimen (*Fig 32*) from the R C S Museum, presented by John Hilton. An extensive villous papilliferous carcinoma of the bladder can be seen the infiltrating character of which is displayed in the section (*Fig 33*). The secondary deposit is in the radius (*Fig 34*), and the microscopic section from this reproduces the transitional papilliferous carcinomatous structure very exactly (*Fig 35*).



FIG 32.—Primary papilliferous carcinoma of bladder. The whole of the inner surface is studded with growths. R C S Museum, 1780 1 (presented by J Hilton)



FIG 33.—Section of tumour of bladder shown in *Fig 32*. A papilliferous infiltrating growth is shown.



FIG 34.—Deposit in radius secondary to growth of bladder shown in *Fig 32*. Tumour partly excised. R C S Museum, 2117 1

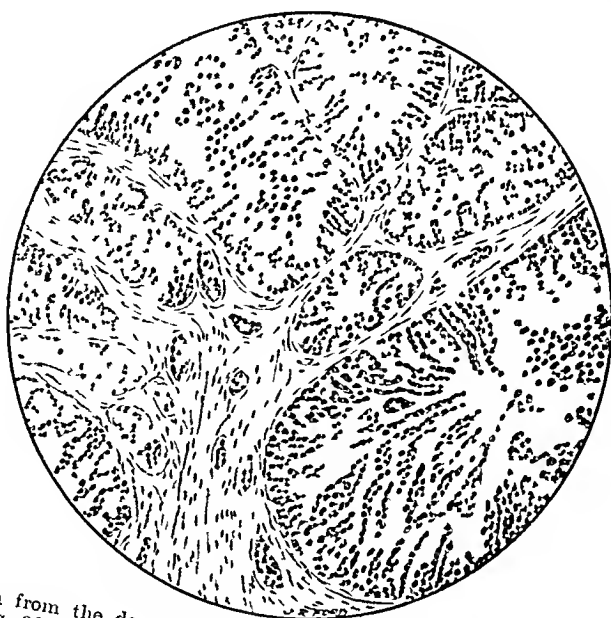


FIG 35—Section from the deposit in the radius (Fig 34) secondary to tumour of bladder (Fig 32). The papilliferous structure is very strikingly displayed.

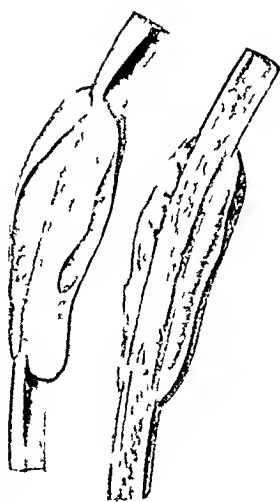


FIG 36—Deposit in rib (bisected) showing secondary growth following tumour of renal pelvis shown in Fig 37. R C S Museum, 2103 1



FIG 37—A papilliferous carcinoma of the renal pelvis causing hydronephrosis. R C S Museum (Hunterian Collection) 519

A metastatic deposit in the skull secondary to a bladder growth is preserved in St Thomas's Hospital Museum (Nos 2171 and 611 and see Clutton⁵³) and there is another in the tibia in St Bartholomew's Hospital Museum (No 508).

Closely related to this group is the papilliferous transitional-celled carcinoma of the ribs (*Fig 36*) secondary to a growth in the renal pelvis (*Fig 37*) both of which specimens are in the Hunterian Collection. The primary growth fills the renal pelvis and has caused hydronephrosis. The microscopic section (*Fig 38*) from the metastasis while confirming the nature of the



FIG 38—Section of tumour shown in *Fig 36*. The papilliferous structure is not well marked.



FIG 39—Tumour removed from lower end of humerus. The primary growth was a hypernephroma. R.C.S. Museum, 20881.

growth does not reproduce the papilliferous structure so well as does the metastasis from the vesical growth above.

The Kidney is well represented among specimens with metastases in bones. One of the most interesting was presented to the R.C.S. Museum by Sir John Bland-Sutton^{51, 55} a tumour removed by resection from the lower end of the humerus, six years before death (*Fig 39*). It was originally thought to be a primary neoplasm. *Fig 40* shows the right kidney and adrenal from the same patient, removed after death. The primary growth appears from Dr Shaw Dunn's examination to be a hypernephroma, and the adrenal growth is apparently, like the humeral deposit, a metastasis. There are several such cases on record. In St Mary's Hospital is a clavicle containing a deposit from a hypernephroma removed by Mr V. W. Low⁵⁶ (and referred to by him in the discussion on "Secondary Growths in Bone" at the Royal Society of Medicine

in 1920) Mr Cope has kindly informed me of a similar case of his own, involving the humerus. Dr Nicholson⁵⁶ has described a deposit in the tibia secondary to an embryonal tumour of the kidney. Mr Nitch⁵⁶ described two cases of adrenal growths with secondary deposits in the humerus and forearm



FIG. 40.—Right adrenal and kidney from same case as Fig. 39. The adrenal mass is like the humeral one secondary to a hypernephroma. R.C.S. Museum 17361

bones respectively, in both of which the secondary tumour was detected before the primary lesion. Winkler³² refers specially to the tendency of adrenal neoplasms to remain for long periods symptomless, so that the metastases they so often produce in the bones are treated as primary tumours. He also calls attention to the way in which these tumours invade the renal

vein and thus eventually the inferior vena cava whence emboli readily reach the right side of the heart. There is a good specimen in the London Hospital Museum (No. 681A) of that variety of adrenal tumour which occurs in children and (as Hutchison²⁰ describes) gives rise to metastases especially in the skull.

Testicular Tumours also may have secondary deposits in the bones. There is a preparation in University College Hospital Museum from a case under the care of Mr. Buntington in which the primary tumour is soft and yellow from necrosis with some fibrous trabeculae dividing it into lobes. It does not invade the spermatic cord. Microscopically it is composed of cells arranged in alveoli and containing lumina. The cells stand in many places directly on capillary walls. The secondary growths in the lungs resembled large round-celled sarcoma but the growth is described as probably an endothelioma. The deposit in the spine involves the eleventh dorsal to the fourth lumbar vertebrae. The brownish haemorrhagic growth has invaded the spinal canal and destroyed the body of the first lumbar and a good deal of the second lumbar and twelfth dorsal vertebrae. The patient age 40 had had for nine years before death an enlarging left testicle following a kick from a horse. Paraplegia and other evidences of the spinal deposit appeared three and a half years before death and two years before that event the spine fractured spontaneously. There is also a specimen in the same museum (No. 78R) of a secondary deposit in a rib, from a primary epitheliomatous growth of the penis.

The Female Generative Organs provide a number of examples of tumours which metastasize in the bones, although I have been unable to find a single specimen of a primary growth in the ovary in this category. In the Museum of the R.C.S. is a preparation which shows a mass of growth in the parietal bone, projecting considerably from its outer surface, and, to a slight



FIG. 41.—Deposit in upper end of femur secondary to carcinoma of tongue. There is a spontaneous fracture. R.C.S. Museum, 21081.

extent, from the inner Microscopically this is a spindle-celled sarcoma, which appeared twelve months before death in a patient, age 51, who had had hysterectomy done six months before the cranial tumour was noticed. In University College Hospital there is a specimen (No 78K) of a deposit in the right humerus, with a spontaneous fracture, secondary to a carcinoma of the cervix. Like many of the specimens referred to in this paper, it was removed under the impression that it was a primary growth, the swelling having appeared while the uterine symptoms were still trivial.

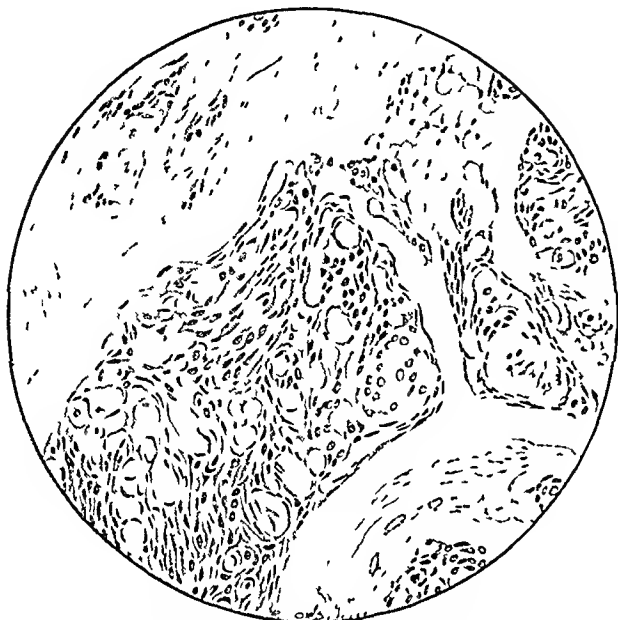


FIG 42—From the deposit shown in Fig 41. The structure is that of a rapidly growing squamous carcinoma.

RCS shows a right femur with a spontaneous fracture due to a secondary squamous carcinoma, the primary mass being in the tongue. The microscopic section of the secondary growth (Fig 42) reveals a rapidly-growing epithelioma with cell-nests and obvious pleomorphic cells. Dr Shaw, Pathologist to the Royal Northern Hospital, has kindly supplied me with details of the post-mortem findings. In addition to a large mass in the tongue and floor of the mouth the glands from the jaw to the bronchi were involved, as well as the pleura, lungs, abdominal wall, small intestine, liver, and femur.

Œsophagus—There are several examples in the London museums of bone deposits secondary to carcinoma of the œsophagus. The one illustrated (Fig 43) is from the RCS Museum, and involves the femur. The microscopic section of this metastasis (Fig 44) fully confirms the nature of the primary lesion. There are two preparations in St George's Hospital Museum (Nos 73D and E) of metastases in the femur, and in the

Tongue—The tongue is not generally believed to give rise to distant metastases. There is such a case on record among those reviewed from the Cancer Hospital post-mortem series, but I can find no details of the case and the specimen has been lost. Fig 41, from a preparation in the Museum of the



FIG 43—Metastatic deposit in head of femur secondary to carcinoma of œsophagus. RCS Museum 2110 1

pelvis and ribs (Nos 73K and 1) also secondary to carcinoma of the œsophagus and a third in the Westminster Hospital Museum of the same sort in the ribs

Alimentary Canal—I have been unable to find a specimen in the museums in London of metastases in bones secondary to carcinoma of the stomach though Colwell¹⁵ found 5 examples in 227 cases—the bones affected being ribs vertebrae humerus and sacrum. In other recorded cases osteoplastic changes seem to be not uncommon, and perhaps as a consequence profound anemia may be a prominent feature. I have also failed to find a tumour of the small bowel with metastases in



FIG. 44.—From specimen shown in Fig. 43. The 'cell nests' are well shown.



FIG. 45.—Section from deposit in humerus secondary to carcinoma of rectum. The adenocarcinomatous structure is unmistakable. *St. Thomas's Hospital Museum, No. 677A.*

the bones but the large gut certainly has this tendency. Rowntree has described a deposit in the skull from a carcinoma of the sigmoid colon,⁵⁶ and there are several specimens associated with carcinoma of the rectum. One such preparation is in St. Thomas's Hospital Museum (No. 677A), a humeral growth in a patient, age 32. Two fractures are present, and the growth coincides very closely in position with the normal distribution of the red marrow in the humerus. The case has been described by Pitts.⁵⁷ The microscopic section (Fig. 45) is from

a preparation made by Professor Shattock, and reveals the structure of a typical adeno-carcinoma such as commonly occurs in the rectum. *Fig 46* shows a deposit in the upper end of the sternum secondary to a similar rectal growth, from a patient, age 35, who had also a deposit in the spine. The specimen is in the University College Hospital Museum (No 78J). In the *Stethoscope*⁵⁸ for December, 1922, a metastasis in the ulna is described, secondary to carcinoma of the rectum. Amputation was performed for the pain and disability, with at least temporary benefit.



FIG 46—Metastasis in upper end of sternum secondary to carcinoma of rectum. University College Hospital Museum 78 J

Liver—Primary growths of the liver occasionally metastasize in bones. The specimen from the Museum of the R C S shown in *Fig 47* is from a case reported by Dr Newton Pitt⁵⁹. The secondary mass in the spine is interesting because although there is a striking degree of angular deformity, due largely to the destruction of one vertebral body, there was no sign of involvement of the cord. The microscopic section (*Fig 48*) is from the spinal deposit, and has an irregularly formed glandular structure, with indications of a columnar type of cell. The primary mass was in the liver.

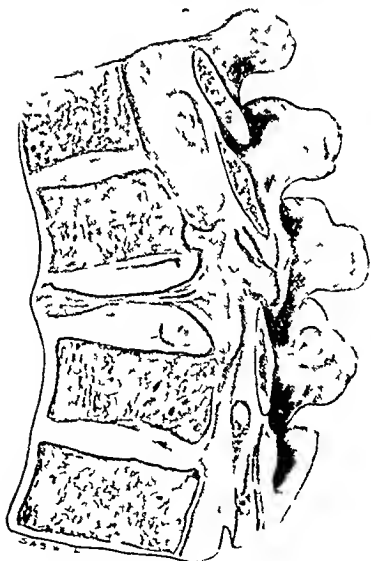


FIG 47—Deposit in spine secondary to primary growth in liver. Angulation due to destruction of body of one vertebra is well seen. R C S Museum 2100 1

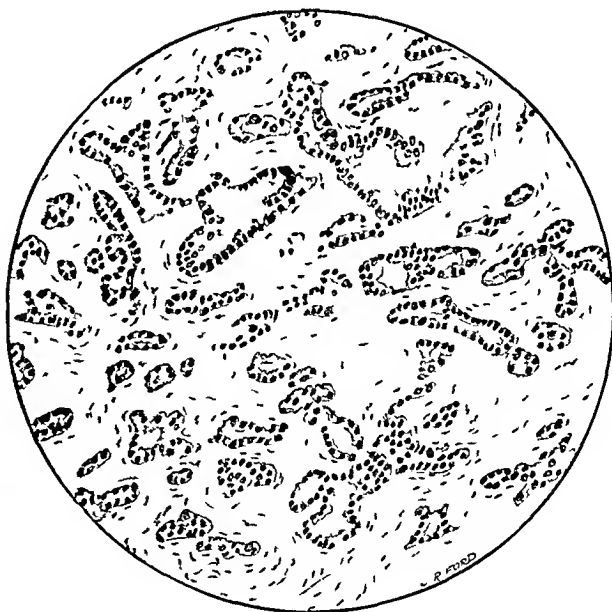


FIG 48—From specimen shown in *Fig 47*. The adeno-carcinomatous structure is similar to that of the primary growth in the liver.

Respiratory Tract—There are one or two metastases from the respiratory tract worthy of note. *Fig 49* from the Museum of the R C S shows many deposits of varying size over the whole skull. It is clear that these when small started in the diploe for only the larger ones have perforated both tables. A section taken from one of these deposits has the structure of a small round-celled sarcoma. The patient a man of 15 had had a sarcomatous polypoid mass in the nasopharynx for a year before the skull tumours appeared, and later many other bones including even the metacarpals and phalanges, became the sites of metastases. In the Museum of Westminster Hospital

FIG 49—Numerous secondary deposits in skull. The primary growth was in the nasopharynx.
R C S Museum, 20521



(No 265A) there are specimens showing deposits in the femur, ribs, and vertebrae from a primary growth of the right lung and pleura.

Bones—It is natural to assume that primary growths of the bones would produce deposits in other bones, and, in actual fact, this is sometimes the case. A preparation in the Museum of the R C S shows a growth secondary to an osteoid sarcoma of the femur in a boy, age 9. The temporal metastasis also exhibits osteoid changes, and a microscopic section taken from the metastasis illustrates the sarcomatous structure, the osteoid changes are pronounced. This case was described by Durham⁶⁰. In the Westminster Hospital Museum are similar ossifying growths in the skull, pelvis and rib secondary to an ossifying sarcoma of the femur (Nos 263A, B, C, D, and E).

Melanotic Sarcoma—Melanotic sarcoma, with its remarkable power of dissemination, does not spare the bones. The specimens illustrated in Figs 50, 51, and 52 are from the Museum of the R C S, and the growths are in the



FIG 50 —Melanotic growth in ribs secondary to primary in thumb
R C S Museum, 2066 1



FIG 51 —From same case as Fig 50 Deposit in upper end of femur Primary growth
was in thumb P C S Museum 2066 2

ribs and the upper end of the femur. The primary growth was in the thumb and there were other secondaries in the glands liver and humerus. All the secondary growths are well pigmented though this is by no means always so. Another series of preparations in the Museum of George Longstaff Esq includes deposits in the ribs sternum and dorsal vertebrae. The primary lesion was a pigmented mole on the shoulder which took on active growth five months before death. In contrast to this rapid dissemination Canns⁶¹ reports a recurrence in the scapula 18 years after the removal of the left eye for a melanotic tumour.

DIAGNOSIS

As a rule diagnosis should be a simple matter because evidence of the primary tumour will generally be available. On the other hand, deeply placed primary neoplasms in stout patients may be missed even when special attention is directed to this

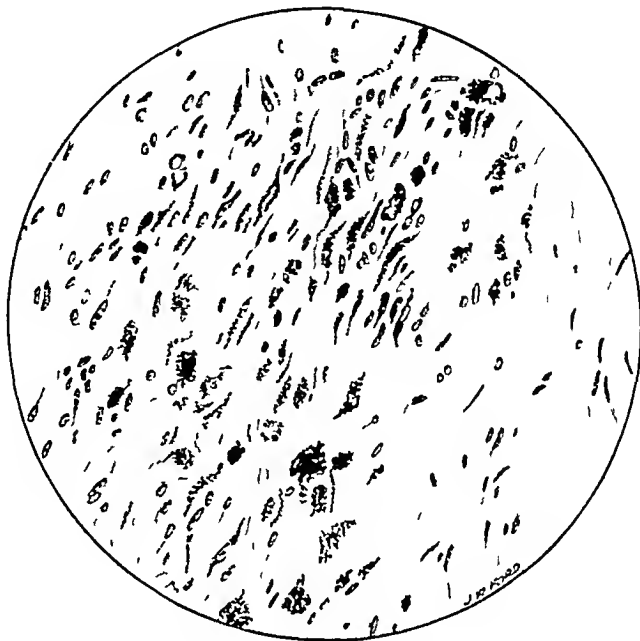


FIG. 52.—From same case as Figs. 50 and 51. The pigmented cells are somewhat spindle-shaped.

possibility. The kidney and adrenal provide good examples of this difficulty. Of the five cases of renal and adrenal neoplasm with metastases in bones mentioned at the discussion at the Royal Society of Medicine in 1920, the latter were in every case treated as primary lesions because of the obscurity of the primary growths. In Mr. Cope's case, which he has kindly allowed me to mention, a growth of the humerus was treated by amputation in a man of 72, and sections proved it to be a hypernephromatous tumour. No evidence of the primary growth could be obtained by palpation or by skiagraphy.

It is proverbially easy to be wise after the event, yet in most cases such as those just mentioned it seems unlikely that any method of investigation could have revealed the primary growth. A hypernephroma may grow very slowly in some cases, yet it may give rise to a secondary deposit, perhaps single, in some remote part, while the primary tumour is still too small to be felt, or detected by radiography. Delbet⁶² asserts that, even after removal, secondary carcinomata of bones may pass as sarcomata because the epithelial elements may be few in number. He reports a tumour of the olecranon which he removed as a primary growth, this opinion while at first confirmed, was subsequently upset by the discovery of a small mass of epithelial cells in the section, and eventually the primary mass was traced to the kidney. Delbet

claims that clinically the distinction between a primary and a secondary tumour of a bone may be almost impossible, especially if the epiphyseal region be involved. Secondary tumours, he says, affect the shaft so much more often than primary tumours that this point has some diagnostic value.

Pain is stated by Delbet to be an unusual symptom in secondary tumours of bone though it is often early and prominent in primary neoplasms. Elmslie⁶³ maintains on the contrary that early occurrence of pain is in favour of the tumour being metastatic. Harrington and Kennedy²⁰ regard pain and tenderness in the bones as highly suggestive of deposits in the bone-marrow.

When the secondary deposit is in the spine, Oppenheimer⁶⁴ states that *deformity* may be the first thing noticed and this is borne out by Pitt's case to which reference has already been made.

The *osteoplastic tendency* shown particularly by prostatic metastases and to a less extent by mammary, gastric, thyroid, and gall-bladder secondary deposits at once distinguishes them from most primary neoplasms, except the ossifying type of periosteal sarcoma, but, as von Reeklinghausen⁶ says, they may still be mistaken for diffuse osteoperiostitic lesions. A Wassermann test may help to eliminate the latter, though as there are other causes of chronic diffuse inflammation of bone besides syphilis, the differentiation may be extremely difficult.

It is almost a platitude to say that the prostate and thyroid should be examined with minute care. A tumour in either which by itself would give rise to little anxiety, may have a special significance when associated with a bone tumour of doubtful nature. There still remain a few cases in which the prostate on the one hand or the thyroid on the other is apparently normal to all tests, yet deeply placed within there is a small malignant nodule, which can only be discovered at autopsy.

Spontaneous fractures occur in both primary and secondary tumours of bone, but in the former the tumour has generally been noticed before the fracture, while with the latter fracture may be the first thing and the tumour is then detected, but in a few there is little evidence externally of a neoplasm at any stage. Union of such fractures is much more likely to follow when the growth is a secondary deposit than when the fracture is associated with a primary sarcoma, this difference being possibly related to the osteoplastic properties of some secondary growths.

I have already mentioned that *anæmia* of a severe degree may be a feature of metastatic tumours of bones, and it has been observed before the deposits in the osseous system became evident—even before the primary tumour. In these rare cases the differential diagnosis depends on such fine distinctions in the blood examination as Pincy has referred to in his paper, which must be consulted for details.

Radiography—X-ray investigation should help materially in the diagnosis of these growths. Bloodgood⁶⁵ holds that the distinction from a primary tumour can be made as a rule, because in the radiogram there is evidence both of bone destruction and of bone formation in the central shadow, while, except in a healing bone cyst, this is never found in primary growths. He, however, admits the difficulty with secondary tumours of bone of prostatic origin, which so closely resemble—even radiographically—ossifying primary sarcomata.

Elmslie says that where the long bones are involved a slight expansion is seen in the radiogram the clear area which lies within giving the appearance of rarefied bone which shades off gradually up and down the shaft into the normal bone. It is this lack of definition of the tumour that he regards as characteristic. Bactjer and Waters⁶⁶ take up very much the same position, stating that it is impossible in the radiogram to determine the point where the normal bone ends and the growth begins. These authors state that in the osteoplastic type of metastasis new bone is laid down only at the periphery of the growth but that this is not so can be seen in the radiogram of the prostatic deposit in the femur from the case I have already mentioned. Nichols⁶⁷ goes still further saying that in bone carcinomata evidence of new bone formation is entirely lacking. Greenough, Simmons and Hamer³¹ state that any metastatic tumour may simulate very closely the radiographic picture of a primary sarcoma since perpendicular spicules are not always present in the latter and not invariably absent from the former.

TREATMENT

Treatment will but seldom be undertaken if the true secondary nature of the tumour be recognized, though severe pain, or the imminence of fungation may occasionally justify amputation. It is perhaps a counsel of perfection to suggest that all bone tumours should be explored and examined microscopically before any radical operation is undertaken but it would prevent the more heroic measures when local operations would be alone justifiable. The beneficial results of such local resections is very well shown by Sir John Bland-Sutton's case. The patient was able to follow his practice as a medical man for nearly six years after the operation which he could hardly have done had amputation been chosen.

PROGNOSIS

As a rule—and this is well brought out in *Table III*—the benefit to be expected from operations on secondary growths of the bones is but transitory, recurrence either locally or in other bones, etc., must soon end life. There are a few striking exceptions. Sir Anthony Bowlby's patient lived nearly six years after the removal of the aim for a secondary thyroid tumour of the humerus. Kiaske's patient (*Table III*) was alive eight years later and free from recurrence. Riedel's patient (*Table III*) was alive ten years after operation, but recurrence was then obvious. Estor and Massabuaun's⁶⁸ patient was alive without recurrence fifteen months after the removal of the thyroid tumour of the clavicle, my own patient is well without recurrence a year after the operation. Elmslie's thyroid tumour of the radius was well for ten months and then was lost sight of. It would seem therefore, that when the exploration of the growth reveals a secondary tumour of thyroid or renal origin, it is a reasonable course to carry out a limited resection of the bone involved where this is feasible, and that in a few instances amputation is justifiable.

I have great pleasure in acknowledging my indebtedness to Sir Anthony Bowlby, President of the R C S, who has kindly given details of his case shown

in *Fig 24*, to Sir John Bland-Sutton for his help in the case of secondary hypernephroma of the humerus, to Professor Shattock for the section of the rectal carcinomatous growth in the humerus, and for help in other ways, to Mr C E Shattock for assistance with the selection of specimens, to Dr Davies, Pathologist of the Miller Hospital, to Dr Shaw, Pathologist to the Royal Northern Hospital, to Dr Shaw Dunn, to Dr Piney, to the Curators of the Museums of the Hospitals in London for giving me access to specimens and for permission to have preparations drawn to Dr Leitch for permission to use the Cancer Hospital records, to Dr Knox for help with the radiographic diagnostic features, and to Mr Sewell and Mr Ford for their care with the drawing of the macroscopic and microscopic preparations respectively

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A DEPRESSED FRACTURE OVER THE ANGULAR GYRUS: CLINICAL AND RADIOLOGICAL LOCALIZATION

By A. P. BERTWISTLE, LINDS

SINCE localized brain lesions due to finite trauma in the vicinity of the left angular gyrus are not very common the following case may be of interest. It occurred in a right-handed quarryman of average intellect who sustained a compound fracture in this region and subsequently developed a mild aphasia. A method was devised rendering it possible to visualize in radiographs the relationship of the underlying gyrus and sulci to the skull as a whole and to the parietal bone.

H. L., age 23, was struck on the head by a large stone. On admission six hours later he was quite conscious but had no recollection of the interval between the accident and his being placed in the ambulance, nor could he remember the accident.

Operation—Ether was administered and an extensive scalp-wound was cleaned. I exposed a depressed fracture of the parietal bone some two inches from the interparietal suture and one inch anterior to the lambdoid suture. The fracture was extensively comminuted, with hairs lying between the fragments. The pieces were removed individually, exposing the brain, all trace of dura having disappeared. The cerebrum was lacerated, and loose portions were swabbed away. The wound was closed without drainage in two layers and 2000 units of antitetanic serum were given.

Clinical Localization—On the day following operation the patient complained of periods during which he was unable to form words. He would break off in the middle of a sentence, unable to continue although obviously trying. When given the word for which he was searching he expressed relief and repeated it. Two days afterwards he was more fully examined. His speech had improved, but he experienced difficulty in naming objects, showing paraphasia, e.g., he called a safety-pin 'single', and watch 'waa'. His power of reading was impaired, he was able to read verbs and nouns correctly, but manifested paralexia in the case of prepositions, adverbs, and conjunctions with marked repetition of the word 'for'. He stated that he quite understood what he was reading, and knew that he was making mistakes. Four days later his writing was examined. He made one mistake in giving his address, calling Station 'Shadown', and pointed to the word as being incorrect. Power of copying printed matter both in type and in writing was good. Reading was better than before, and dictation moderately well accomplished. No motor paralysis was evident, but the right abdominal reflex and left knee-jerk were less easily elicited than those of the opposite sides.

Ten days afterwards his reading was almost normal, but still rather slovenly. The visual fields were normal. The wound had almost healed, and he had suffered from no headaches after the first few days.

The symptoms referring to the cortical lesion are (1) Partial alexia, (2) Mild sensory aphasia, (3) Slight agiaphia. They point to a lesion in the neighbourhood of the angular gyrus. The lesion cannot have been very deep, as hemianopia was absent. It is interesting to note that, although the extent of cortex involved was quite considerable, being $1\frac{1}{2} \times 1\frac{1}{2}$ in area, and although there was laceration of the brain the symptoms were transitory in their nature. The clinical findings were confirmed radiologically as described below.



FIG. 53.—Key radiogram, showing relations of brain to skull.

Radiological Localization—The following method was devised to locate the site of the injury. The half of a sagittally divided skull with a corresponding half of a brain were taken. Between the more important gyri were implanted pieces of copper wire moulded according to the shape of the sulci. The boundaries of the parietal bone—where not obvious—were marked by gluing a thin copper wire on to its margin. The brain was placed in the skull and radiographed lying on its mesial surface, so that the picture is a

true lateral one (*Fig 53*) It will be noticed that horizontal sulci lie nearer the vertex than is shown in text-books The vertical ones show an apparent decrease in length which can only be accounted for by the convexity of the

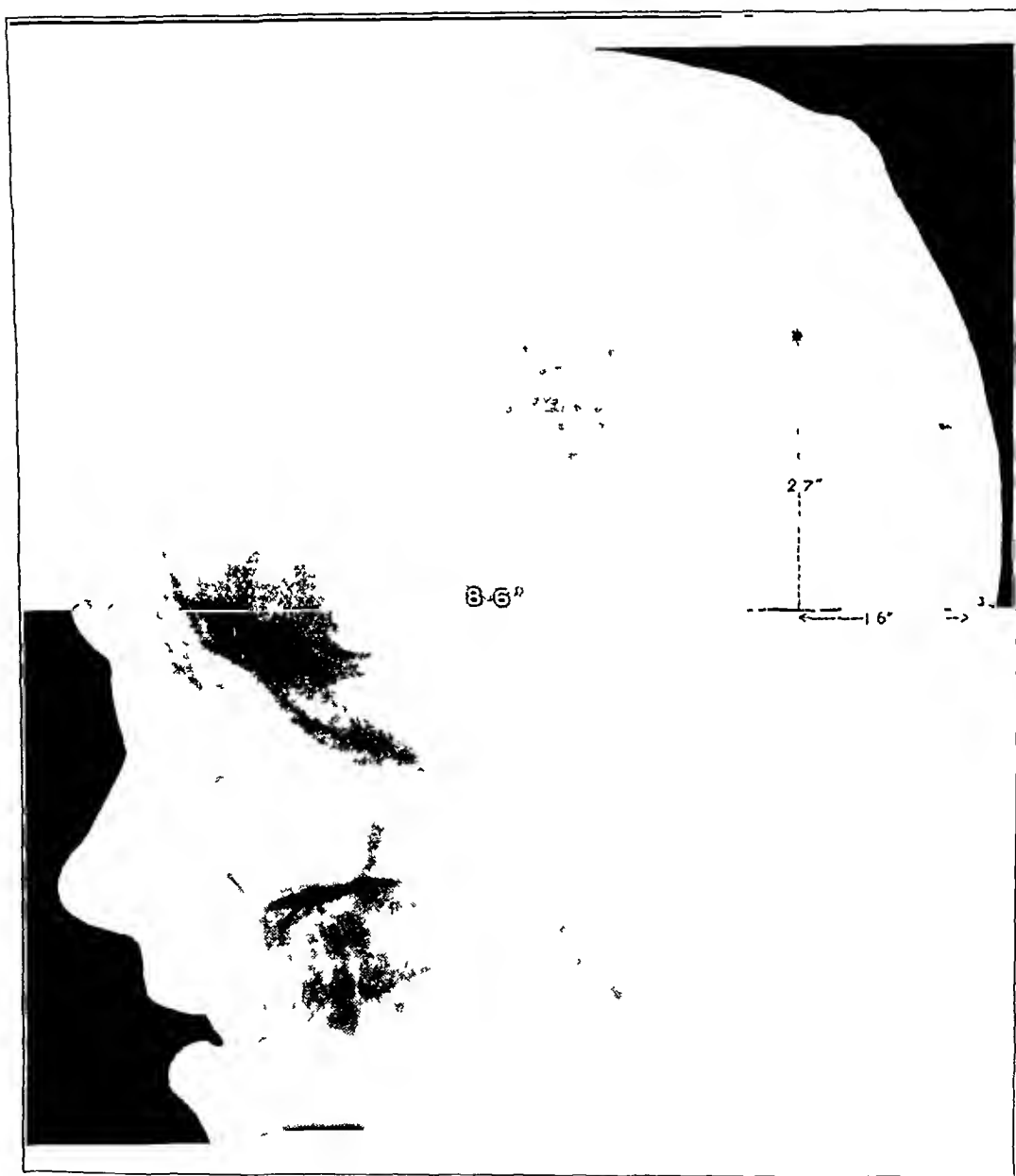


FIG 54 —Depressed fracture over angular gyrus

brain This key radiograph is useful in reading radiographs of skulls, as one cannot compare the latter with the normal cranio-cerebral topographies of manuals, these depict the skull at different angles for the purpose of showing

the vertex. A base line is drawn from nasion toinion on both skiagrams, and by means of lengths along this line and perpendiculars to it localization is possible as is now shown.

It is most necessary that the patient's skull should be in the same position as the key, i.e., purely lateral. This can be accomplished by placing a small lead bead in each external auditory meatus previous to radiography, the shadows cast by these spheres are then adjusted to lie one over the other. In this case the expedient was unnecessary in view of the almost complete superimposition of the inferior dental foramina. The base lines on skull and key measure 8.6 and 9.1 in. respectively, so that all horizontal distances before translation from skull to key must be multiplied by the constant $\frac{9.1}{8.6}$. A perpendicular is now dropped from the middle of the gap in the skull to the base line (*Fig. 51*). It is found to be 1.6 in. from the posterior end, i.e. $1.6 \text{ in.} \times \frac{9.1}{8.6} = 1.7 \text{ in.}$ from theinion of the key. The vertical distance between the base line and the vertex at a point 1.7 in. from theinion, is 4.3 in. on the specimen and 1.5 in. on the key. The actual distance of the middle of the lesion from the base line is 2.7 in., so that the corresponding point on the key is $2.7 \times \frac{4.5}{4.3} = 2.85 \text{ in.}$ From these data it is obvious that the lesion lies over and behind the angular gyrus. It will be seen that the correction for size here is negligible, but in the case of a child it would be all-important.

SUMMARY

1. A depressed fracture of the parietal bone was defined clinically as being over the angular gyrus by slight manifestations of sensory aphasia, alexia, and agraphia.

2. A key skiagram was prepared showing the relation of the skull to the convolutions of the brain.

3. By the use of base lines frominion to nasion and a constant, it is possible to localize, in radiograms, the area of brain involved in injuries of the skull, even though it be that of an infant.

My thanks are due to Mr. J. F. Dobson for permission to publish this case, and also to Dr. Moll for his kind help.

AN OPERATION FOR HÆMORRHOIDS

BY K W MONSARRAT, LIVERPOOL

I HAVE employed the method of operating upon hæmorrhoids which is here illustrated for the last three years, and have found the results satisfactory

Under general anæsthesia the anus is sufficiently dilated to bring the hæmorrhoids fully into view. If spinal anæsthesia is used this dilatation is unnecessary

Three pairs of pressure forceps are applied to the hæmorrhoidal mass on one side of the middle line and it is drawn over to the other side. A curved incision is now made through the skin just beyond the edge of the hæmorrhoidal semicircle (*Fig 55*). The forceps are then applied to the inner edge of this wound. With touches of the knife and

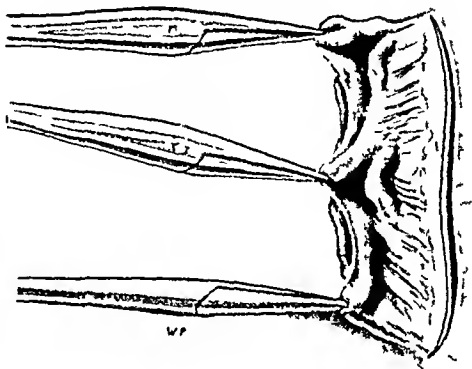


FIG 55—1st step. Pressure forceps applied. They should be shown divergent, putting the hæmorrhoidal mass on the stretch in the sagittal plane

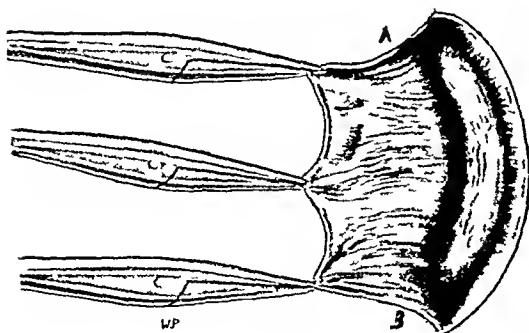


FIG 56—2nd step. Exposure of the external sphincter

by gauze dissection the external sphincter is displayed, separation is continued between this muscle and the lining of the anal canal and rectum as far as may be judged necessary (*Fig 56*). The degree of this denudation will vary with the degree of habitual prolapse. If there is much prolapse, small incisions are made with scissors at each pole of the semicircle (A and B, *Fig 56*), but this is rarely necessary

A clamp is then applied, and the mass cut so as to leave sufficient material beyond the clamp for suture (*Fig 57*). The raw

leave sufficient material beyond the clamp for suture (*Fig 57*). The raw

edge so left is then sutured by a continuous catgut suture to the skin edge (*Fig 58*). The clamp is removed and the suture pulled taut and tied, it is hemostatic. The semicircle on the opposite side is treated in a similar way (*Fig 59*). The wound is lightly wiped with B I P P.

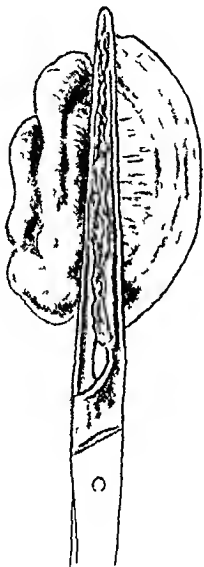


FIG 57—3rd step. Half of the mass cut away

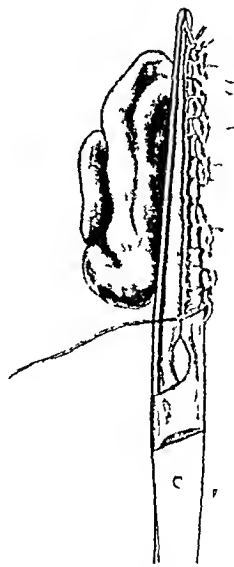


FIG 58—4th step. Raw edge sutured to skin edge

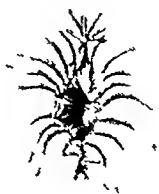


FIG 59—The operation completed

The operation deals radically with the varices and also with any prolapse that may be present. Occasionally one or two arterioles are severed by the primary incision and need ligature, usually there is no hæmorrhage at all. The external sphincter comes fully into view and cannot be injured.

RETROGRADE INTUSSUSCEPTION OF THE SMALL INTESTINE AFTER GASTRO-ENTEROSTOMY.

By HAMILTON DRUMMOND NEWCASTLE-UPON-TYNE

DURING the last few years cases of retrograde intussusception of the jejunum following gastro-enterostomy have been recorded and recently one such came under my care. As this is a rare but now a well recognized complication of this operation I think a record of my own case with abstracts and observations from others may be of interest. Hitherto eleven cases have been recorded, two of them in this country—one by Richard Warren, another by St Bartholomew's Hospital—and the remainder on the Continent. My own case will make twelve in all.

The chief interest in the condition lies in the difficulty of explaining the factors which are responsible for the occurrence of this retrograde intussusception, why it should occur in a few cases only, and also what steps ought to be taken to prevent relapse as in the case recorded by Baumann.

AUTHOR'S CASE

R. H. B., age 35, a platelayer by trade, was admitted to the Royal Victoria Infirmary on July 25 1922 complaining of severe spasmodic pain in the abdomen. He stated that he was well up to 10 a.m. on the previous day when quite suddenly after taking food he experienced severe pain in the epigastrium. The worst pain came on in spasms, but it had also been continuous up to the time of his admission. He vomited freely after the pain commenced, and frequently during the day and night up to the time he was seen in the Royal Infirmary. At first the vomit consisted only of food which he had taken, but later it contained blood and the specimen seen, which he brought up after being in hospital one hour contained dark-coloured liquid blood and was foul smelling. He had passed no flatus, and his bowels had not been moved since the previous day, just before the pain came on.

On examination, he looked ill. His temperature was 98° and his pulse 96. His tongue was dry and furred. There was a mid-line incision the result of a previous operation above the umbilicus. The abdomen moved well on respiration and no mass was palpable nor was there any definite amount of tenderness or rigidity. Rectal examination was negative.

During the short time he was in hospital before operation he had several attacks of pain accompanied by vomiting of blood.

Previous History—This was kindly given to me by Professor Francis Cand, of Edinburgh, who had operated upon him on two previous occasions for chronic duodenal ulcer the first time sixteen years ago.

“March 3, 1906—One year ago he complained of sudden pain in the stomach and swelling of the abdomen, not affected by taking food. It was so severe that he

took to bed, and after resting, with relief, the symptoms returned and he was obliged to be up again. Now he began to vomit brown frothy sour-smelling fluid—no relation to food. He has been off work for a year, and for the past nine months has never been free from pain. He is always constipated, but has never vomited blood. No melæna. Test meal showed hydrochloric acid abundant. Stomach holds 3½ pints. No peristalsis seen. Stomach when full descends to about one inch above the pubis.

Operation, March 6—Through a mid-line incision. Stomach lay completely above the umbilicus. Firm adhesions between the anterior surface close to the lesser curvature and the anterior abdominal wall. The omentum was adherent to the abdominal wall also. The stomach was large and hypertrophied. The pyloric end was firmly buried in adhesions, which also involved the duodenum. The adhesions were divided with scissors, exposing a very thickened and stenosed pylorus. All the coils of small intestine lay on the right side of abdomen below the liver, to the right of the ascending colon and hepatic flexure. The cæcum and appendix lay far to the left of the mid-line. To get a suitable loop of jejunum for gastro-enterostomy, the adhesions covering the duodenum had to be liberated with a blunt dissector. It was considered advisable to perform a Roux Y operation. The opening in the mesentery of the jejunum was stitched up and also united with another portion of mesentery to avoid the probability of an internal strangulation.

He made a good recovery, and on March 19 was on full diet. On March 22 he left for the Convalescent Home.

He was re-admitted on April 20, 1909, complaining of pain twenty minutes after food, associated with vomiting. Since leaving hospital after the operation in 1906, although he did not put on much weight, he was in the best of health until December, 1908. Then sharp pains were experienced in the gastric region twenty minutes after a meal. They did not enter into his back. He had no vomiting, nor had he melæna. At times frequent heartburn and waterbrash, accompanied by flatulence, troubled him very much. His bowels became irregular and failed to act daily. The pain steadily became more severe, lasting on an average for three or four hours. In February, 1909, he began to vomit at odd times about once every three weeks, three or four hours after a meal, sometimes he would vomit during the night. The vomit at that time was brownish and frothy. During the last three months he has lost fourteen pounds in weight. The stomach stands out in rigid spasms at times, peristaltic waves passing from left to right. Marked splashing of the lower border of stomach at umbilicus. There was no tumour palpable, no tenderness. Test meal showed stomach to contain plenty of hydrochloric acid.

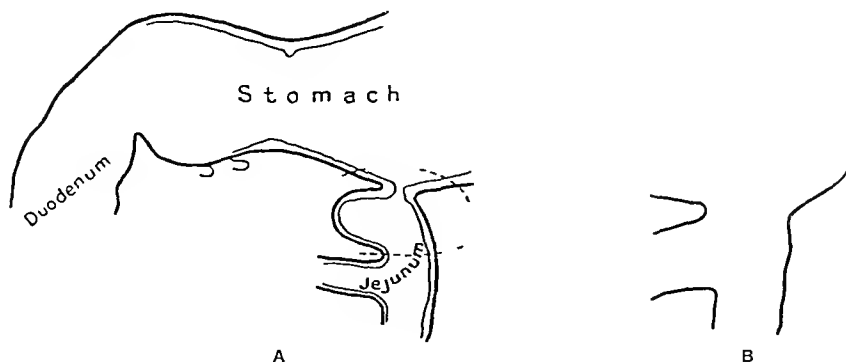


FIG. 60.—Removal of gastro-enterostomy opening and pouch below.
(A) The dotted lines show the area resected. (B) After resection and suture.

Second Operation—He was kept under observation for some time, and on May 3, 1909, was operated upon for the second time. On opening the abdomen the relations to the large and small intestine were not so abnormal as at the former

operation The gastric stoma was very much narrowed The pylorus was larger than when previously noted There were several enlarged glands, one of which was removed for section The stoma and adjacent portion of the jejunum were removed, and a fresh union above the Y to the stomach was made From the diagram (Fig 60) it will be seen that the portion of jejunum close to the stomach had become pouched This was removed "

The patient left for the Convalescent Hospital on May 25, 1909, feeling very well, and he remained well until his present illness

Present Illness—

Third Operation July 25, 1922, two hours after admission—On opening the abdomen through the old scar, 35 hours after the onset of acute pain, very few adhesions were found between the viscera and the abdominal wall Posterior gastro-enterostomy had been done with a long loop The proximal loop was enormously distended being three or four times its normal size This dilatation commenced at the first part of the duodenum, and ended at the junction of the jejunum with the stoma, the portion of stomach between the stoma and pylorus was small and atrophied, and was covered in by old fibrous adhesions The distal side of the bowel below the anastomosis for about six feet had become intussuscepted into the stomach through the stoma The intussuscepted gut was easily reduced It was very oedematous, and showed areas of hæmorrhage into its walls having in every way a similar appearance to the intestine found in cases of ilocolic intussusception My first impression was that the gut was being reduced from the lesser sac, but this was found not to be the case and the lesser sac was connected with the greater by a large opening in the mesocolon The stoma was situated almost on the greater curvature of the stomach, and admitted two finger-tips when palpated through the jejunal wall Owing to the man's shocked condition it was decided to do nothing more after reduction of the intussusception

Fourth Operation, Aug 10, 1922—He made a straightforward recovery from the last operation and his wound having healed by first intention, and his temperature and pulse being normal his abdomen was again opened with a view to attempting to prevent further recurrence of the retrograde intussusception of the small intestine into the stomach Again the mid-line incision was used, and a new anastomosis was made between the stomach and the jejunum, after separation and suture of the old one A proximal portion of the jejunum was taken to the old site of anastomosis leaving no loop The duodenum and the upper part of the jejunum were again noticed to be very distended and hypertrophied (The appendix and cæcum were in the left side of the abdomen, high up in the position of the spleen, as noted by Professor Cand at his first operation)

The patient made a straightforward recovery, and went home on Aug 14 He was seen from time to time in the out-patients' department, and continued to do well

On Nov 1 he was again re-admitted to the hospital, with the following history Since he returned home on Aug 14 he had been in excellent health until the previous evening (twenty-four hours previous to admission), when whilst playing cards in the house, he was suddenly seized with very severe pain in the epigastrium which he states, 'dropped' him He was then

just able to get up stairs without assistance. After getting there he fainted, was put to bed, and the doctor was sent for. He did not sleep at all during the night, and was unable to take any food but had not vomited up to the time of his admission to hospital next morning. The bowels had been moved on the morning before his attack at 10 a.m.

On examination, after being in hospital for an hour he was found lying on his left side. He stated that he felt a little better, but the pain which was continuous, and not in spasms as it had been in his previous attack was still present. He did not look so ill as he had done on the last occasion. His pulse was 128 and his temperature 99.8° . His tongue was clean. When asked to turn on his back he did so but only slowly and with difficulty. His abdomen was distended in the upper part and respiratory movements were almost absent. He was tender on deep pressure on the right side, and there was marked rigidity of both recti muscles above the umbilicus. Liver dullness was diminished but present. He was dull in both flanks more marked on the left side. No mass was palpable.

Fifth Operation Nov 1 1922—A diagnosis of perforated viscus was made possibly a jejunal ulcer, and he was operated on at once twenty-five hours after the onset of pain. The old mid-line incision above the umbilicus which had healed well was opened up. There was purulent fluid in the abdomen among the coils of small intestine which were distended and intensely injected. On exploration of the stomach in the gastro-enterostomy region which was shut off by plastic lymph gas escaped from a small hole the size of a goose quill. This was found to be in the loop of jejunum just beyond the gastro-jejunostomy opening which had been made two months before. The loop of proximal jejunum and the duodenum were still dilated but this was nothing like so marked a feature as had been noted on the previous occasion. The ulcer was closed by a purse-string suture of catgut followed by three interrupted Lembert sutures of silk. Considerable thickening round the ulcer appeared to be due to jejunum oedema the result of recent inflammation. The abdomen was mopped out with saline mops and it was found that fluid was present as far down as the pelvis. The caecum on this occasion was noted to be in its normal position but with a very long mesentery. The abdomen was closed by sutures in layers.

The patient made a straightforward recovery. The wound healed well, and on Nov 4 he was eating chicken. He left hospital on Dec 8 perfectly healed and on ordinary diet with directions to take for at least a year regular large doses of the mixed alkalis, carbonate of soda, magnesia and bismuth.

CASES RECORDED IN THE LITERATURE

Lundberg¹ describes a case of his own of retrograde intussusception following gastro-enterostomy and records eight other cases of a similar kind.

His patient was a woman, age 48, who had been operated on in 1911, and at that time was supposed to have carcinoma of the stomach. The pyloric end of the stomach was resected and an anterior gastro-enterostomy with entero-anastomosis performed. The stomach was very large, and there was a definite tumour at the pylorus. She had remained well up to twenty-four hours before she came under his care in 1921. She then complained of pain in the upper abdomen, and vomiting, and was unable to

account for this by any error in diet. The vomited matter first contained bile and afterwards blood. On admission to hospital her temperature was normal, pulse feeble, 100. She had pain and repeated vomiting attacks, the vomited matter containing blood. The abdomen was not distended. A tumour could be distinctly felt under the left lower ribs, about two fingers in breadth. It was hard and mobile. The patient grew worse in spite of stimulants and saline transfusion. On the following day the vomiting of blood ceased, but she grew worse, and died four days after her initial attack. There was no operation in this case on account of the patient's bad general condition.

Post-mortem showed that the distal loop of jejunum was intussuscepted in a retrograde direction upwards into the stomach. It entered the anastomosis through the distal loop of jejunum to the gastro-enterostomy opening. The intussuscepted bowel in the stomach was twenty inches in length. It was much inflamed. The stomach and intussuscepted intestinal loops were filled with fluid blood. There was no peritonitis and no growth present.

Other cases quoted by Lundberg may be briefly mentioned —

Steber's case 2—

A woman, age 21, was operated upon by Steber for stomach trouble. Posterior gastro-enterostomy was done. She was seven months pregnant and had suffered from vomiting the whole of this time. She was suddenly seized with severe pains in the stomach with violent vomiting, and four hours later blood was noticed in the vomit. A diagnosis of bleeding ulcer was made. The cramplike pains in the epigastrium continued, but there was no rigidity. She died on the third day after the initial symptoms.

Post-mortem examination showed an intussusception of the distal jejunal loop of the jejunum into the stomach 30 cm. in length. The base of the intussusception appeared to be at the gastro-jejunostomy opening.

Baumann's case 3—

A woman, age 44, had been operated on for ulcer of the duodenum. The pylorus was occluded and anterior gastro-enterostomy was performed with entero-anastomosis. An intussusception into the stomach was reduced, and the patient did well. Eight weeks later she had a return of the same cramping pains, and twenty-four hours after the commencement of her second attack a tumour could again be felt, which was lying a hand-breadth below the umbilicus on the left side. She vomited 1½ litres of foul-smelling liquid and after this the tumour was noticed to be at a higher level. The condition was diagnosed (retrograde intussusception), and the abdomen was opened again. The base of the intussusception was now lying about 25 cm. below the entero-anastomosis, and the apex reached to the gastro-enterostomy opening. It was not possible to reduce the intussusception completely, and about 10 cm. of intussuscepted gut was resected.

The patient was operated upon later for intestinal strangulation, after which she recovered.

Hatert's case 4—

A man, age 30, was operated on for perforated ulcer of the stomach, which was closed by suture and a posterior gastro-enterostomy performed. Nine months later he was taken ill during the night with severe pains in the stomach and vomiting. On the following morning the vomiting continued and he brought up blood. The stomach was distended, but the remainder of the abdomen was normal. Under the left rib margin was a tumour the size of a fist. Operation was performed, a diagnosis having been made of obstruction in the jejunum. It was found that a loop of jejunum was intussuscepted into the stomach for 30 cm. The base of the intussusception was thought to be at the margin of the gastro-enterostomy opening.

Reduction was performed and the patient recovered.

Schloessmann's case ⁵—

A woman, age 42, had been operated upon ten years previously for a growth of the stomach and gastro-enterostomy had been performed. She was ill for two days, and complained of severe sudden pain in the abdomen. Half an hour later vomiting began which continued day and night, accompanied by repeated cramps in the stomach. At first the vomit contained bile, and in twenty-four hours blood was noticed, which became more marked later on. The abdomen was not distended or rigid, though the recti in the region of the epigastrium were contracted and tender. The remainder of the abdomen was soft, and there was no distention. At the level of the umbilicus, lying horizontally, there was a swelling about the size of a fist which was tender on pressure. A diagnosis of intestinal obstruction high up in the small intestine was made. At the operation 40 cm of the distal jejunal loop was found intussuscepted into the stomach through the gastro-enterostomy opening. The intussusception was reduced. In order to prevent this happening again the distal loop of jejunum was sutured to the colon.

An uneventful recovery followed, though three weeks after operation the patient complained of severe short cramping pains.

Anbeiger's case ⁶—

A man, age 43, five years previously had had inferior gastro-enterostomy performed with entero-anastomosis. There was marked pyloric obstruction. The patient for several years was free from pain and then began to have severe vomiting, which became frequent, and he was unable to get his bowels moved or to pass flatus. He was in very bad condition. At the operation 12 cm of the distal loop of jejunum was found to be intussuscepted upwards, with the apex of the intussusception close to the entero-anastomosis.

Resection was undertaken and the patient recovered.

Lundberg also mentions two cases which came under the care of Eberle,⁷ where the distal jejunum loop became the seat of an ascending intussusception. In these cases anterior gastro-enterostomy had been performed. They were operated upon and both recovered.

The following case came under the care of Mr Richard Warren⁸ of London —

E S, a male, was admitted into the London Hospital suffering from hæmatemesis. Thirteen years previously gastro-jejunostomy had been performed at another hospital for some stomach lesion. The patient made a good recovery, and remained well for twelve years.

One year before admission he began to suffer from abdominal pain after meals, accompanied by vomiting. The sickness relieved the pain. At times he would be free from stomach trouble for a period extending over a month. Two days before admission he had a very bad attack of pain associated with hæmatemesis, which continued up to the time of his admission. On examination he was found to be very ill, and showed the abdominal freces. The pulse was 100. There was considerable vomiting of large quantities of blood-stained fluid. The abdomen was flaccid, and an indefinite elongated mass was palpable above and to the left of the umbilicus. On account of the softness of the mass, the suggestion that it was due to a peptic jejunal ulcer was dismissed.

At the operation a few adhesions were found binding the transverse colon to the abdominal wall. These were separated. The stomach and pylorus appeared to be normal. On turning up the stomach to examine the stoma the distal loop of the jejunum was found to be turgid and purple for 8 inches, where the entrance of a retrograde intussusception was found. The intussusception passed up the distal jejunal limb, its apex projecting about 3 inches into the stomach through the stoma. The reduced gut was very cedematous and purple, but at no point could any thickening suggestive of ulceration be felt. The abdomen was closed.

The patient vomited some brown fluid on the day following the operation, but continued to improve until the seventh day, when respirations became rapid and he had foul offensive sputum. Death occurred on the tenth day.

Post-mortem showed the lungs to be in a condition of severe bronchial pneumonia with multiple abscesses. The abdomen was healthy except for slight plastic peritonitis about the site of the intussusception and some bruising of the intestine. The gastro-enterostomy as seen at the operation proved to be in excellent order. The stoma was of good size and well placed. There was no sign of any peptic ulcer in the jejunum.

Case reported by Dr. Ainspigel⁹ —

A woman, age 59, had posterior gastro-enterostomy performed for pyloric stenosis. Eight days later she had an entero-anastomosis done owing to symptoms of vicious circle. She remained fairly well after this until eleven and a half years later, when she was suddenly seized with colicky pains in the stomach, with coffee-ground-like vomiting. On the following day (twenty-four hours after onset of pain) her general condition was good, pulse was 100, the abdomen was flaccid, and in the left hypochondrium on deep palpation there was definite resistance found.

Operation was performed twenty-four hours after onset of pain, and stomach and omentum were found to be adherent to the anterior abdominal wall. After freeing and retracting the stomach and colon a sausage-shaped intussusception was found. The first part of the small intestine was very distended. The intussusception lay 20 cm. below the gastro-enterostomy. The apex was close to the entero-anastomosis. Reduction was accomplished with some trouble by pulling and squeezing the intestine. The entero-anastomosis appeared to be very wide, and the gastro-enterostomy was acting well. The abdomen was closed in layers without drain and recovery was straightforward. One month after operation the stomach and bowels were acting perfectly well and the general health was excellent.

The patient later stated that during the first year after her first operation she had three attacks of stomach colic but without any vomiting. They were similar to the present attack, and had been cured by massage. These attacks lasted from two to three hours. She was unable to account for the attacks.

ETIOLOGY

The condition known as retrograde intussusception has been recognized for a long time, and occurs apart from gastro-enterostomy. Leichtenstein,¹⁰ after careful examination of the literature on this subject, found that out of 593 cases of intussusception only 8 were of the ascending type. According to Baumann's statistics, one ascending intussusception occurs to 200 descending cases.

There can be no doubt that in the cases to which I wish to draw attention the gastro-jejunostomy is in some way the primary cause of the ascending intussusception. There is one thing quite certain, and it is that whatever the cause of the retrograde intussusception be, it is not due to any misplacement of the stoma between the stomach and the intestine. It does not appear to matter which type of gastro-jejunostomy has been performed. Of the twelve cases in which intussusception occurred, five were anterior gastro-enterostomies, five posterior, and in the remaining case no note was made.

In some of the cases an entero-anastomosis had been performed in addition to the gastro-enterostomy, in fact, it is a point of special interest to note that this had been done in five of the twelve cases.

Retrograde intussusception has also been recorded to occur above a stricture of the small intestine as if attempts on the part of the bowel to

empty itself by forcible antiperistalsis had been made. Riedel¹¹ records a case of ascending intussusception of the colon some distance above a descending intussusception.

The most reasonable cause of ascending intussusception in these cases appears to be as follows. In the first place, there must often be a tendency in cases of gastro-enterostomy for the stomach to empty itself through the stoma more rapidly than is normal, its acid contents causing some irritation of the upper jejunum, as was shown by the development of a ruptured peptic jejunal ulcer in my case. This fullness and acidity of the contents of the upper jejunum might result in forcible antiperistaltic action, the contents being regurgitated into the stomach through the stoma which, unlike the pylorus, has no power of preventing this, as it is possessed of no sphincter action. Then, when the intestine enters the stomach, further portions of it are drawn in by the efforts of the stomach to eject its contents.

SYMPTOMS AND DIAGNOSIS

Having once seen a case of ascending intussusception following on gastro-enterostomy, the symptoms are definite enough to suggest a diagnosis of the condition. It appears that Baumann made an accurate diagnosis in his case as the same condition recurred eight weeks later. These symptoms following gastro-enterostomy are sudden attacks of cramping pain in the epigastrium, followed at first by vomit of food and bile and later of blood, inability to pass flatus and to have the bowels moved. Rigidity and distention do not appear to be often present nor is tenderness constant. In six of the known cases a tumour was noticed. In all cases so far as is known where the intussuscepted intestine reached the stomach blood in the vomit was a marked feature. By this time the strangulation and interference with the blood-supply would be acute and explain this symptom. Though the facial aspect denotes a serious illness, rise in temperature does not seem to be a prominent feature.

It is a noteworthy fact that in the majority of cases intussusception occurred a long while after gastro-enterostomy had been performed. In nine of the twelve cases recorded, where definite dates are given, the invagination occurred 15½ years, 12 years, 11½ years, 10 years, 10 years, 5 years, 5 years, 1½ years, and nine months after the operation of gastro-enterostomy, making the average nearly 7 years after the first operation.

In two of these the patients were pregnant. One, a woman 21 years of age, was seven months gravid (Steber's case), and had suffered from the commencement of her pregnancy from persistent vomiting, when suddenly this, accompanied by pain, became very much worse and she vomited blood four hours later. The symptoms continued until she died on the third day. Post-mortem showed 30 cm. of the distal limb of the jejunum to be lying in the stomach.

In the second case, for the notes of which I am indebted to the authorities of St. Bartholomew's Hospital Museum, a woman was admitted to hospital for persistent vomiting in the thirty-fourth week of her second pregnancy. She died three days later, and post-mortem showed 2 feet of distal loop of

jejunum intussuscepted into the stomach through the stoma (*Fig 61*) Gastro-enterostomy in this case had been performed five years previously

In these two cases it would seem that persistent vomiting, the result of the pregnancy, may have played a part in producing the intussusception

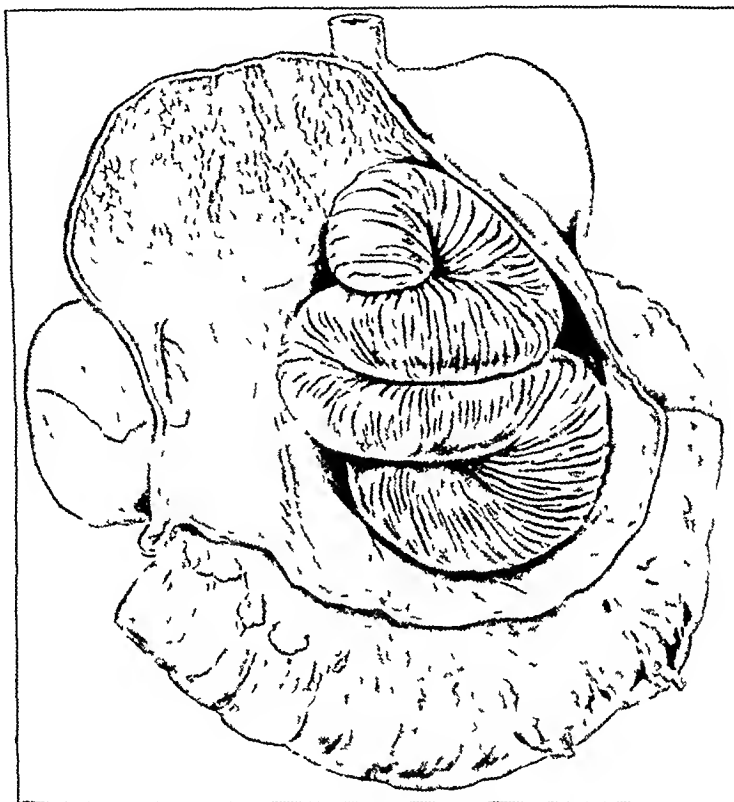


FIG 61—Retrograde intussusception of small intestine into the stomach through the stoma of a posterior gastro-enterostomy which had been performed five years previously. Two feet of intussuscepted jejunum are seen lying in the interior of the stomach. The pyloric opening and duodenum are seen on the left hand side of the illustration.

(From a specimen kindly lent by St Bartholomew's Hospital Museum.)

TREATMENT

The treatment of this condition is certainly as in all forms of intussusception operation. It is difficult to know what could assist in preventing the condition from occurring a second time as in the case recorded by Baumann. Schloessmann in his case sutured the involved loop of jejunum to the colon, after reduction of the intussusception. In my own case, partly on the ground of enormous distention of the proximal loop of jejunum, and to prevent perhaps a further recurrence a second operation was performed ten days later when a fresh stoma was made in the stomach attaching the loop of jejunum higher up the bowel making a short-loop junction. This, unfortunately did not prevent the patient from returning to hospital eleven weeks later with an acute ruptured peptic jejunal ulcer as recorded in the notes

Since this paper was completed, two more cases have come under the author's notice, reported by Lewisohn¹³ and Delhno¹⁴. In both cases the intussusception occurred a short while after gastro-enterostomy had been performed.

CONCLUSIONS

1 Retrograde intussusception of the small intestine is now a well-recognized complication following gastro-enterostomy. Fourteen cases have been recorded.

2 The type of gastro-enterostomy performed has nothing to do with the occurrence of the ascending intussusception.

3 In all probability the ascending intussusception is caused by too rapid emptying of the stomach causing irritation of the jejunum and setting up forcible antiperistalsis.

4 Diagnosis is straightforward, and should now that the condition has been recognized, be easily made.

5 The history of a previously performed gastro-enterostomy, often of many years' standing followed by sudden griping epigastric colic, vomiting of blood, often a palpable tumour in the left hypochondriac region with absence of rigidity, distention, and acute tenderness suggest the diagnosis.

6 The treatment of the condition is immediate operation.

7 A reliable preventive treatment has not been suggested.

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CHRONIC MASTITIS

BY GEOFFREY KEYNES, LONDON

*(Being the Hunterian Lecture delivered at the Royal College of Surgeons of England
on May 9, 1923)*

THE PATHOLOGICAL PROBLEM PRESENTED BY MASTITIS

THE pathological problem underlying the clinical condition known as chronic mastitis is one that is ever present to those engaged in the practice of surgery yet the current ideas concerning it are usually vague and often, I believe, erroneous. It is known to be an exceedingly common condition though only those patients present themselves for treatment who suffer from the extreme degrees of it, so that it is certainly even commoner than ordinary clinical experience would suggest. Many women through long habituation come to regard a certain degree of pain in their breasts as a normal state of affairs, and consequently never seek advice concerning it. To those who do come to the surgeon the treatment that is meted out is often unsatisfactory for the local application of a belladonna plaster and advice as to wearing a support, can only be regarded as palliatives of doubtful value.

The condition is most often seen in women nearing the menopause that is to say, between the ages of 40 and 50 years. The patient complains of an aching or dragging sensation in one or both breasts. Sometimes she will state that there are pricking pains at different points in the breast, and nearly always there is an increase in the symptoms at the menstrual periods. Sometimes she will state that there is an intermittent discharge of fluid from the nipple, but usually this is not noticed.

On palpation the breast is found to be tender especially at certain points, and if the patient be stout this is often all that can be made out. If the patient be thin the breast substance is found to have a characteristic lumpy feeling, and the gland may be diffusely enlarged. Usually no definite tumour can be felt but the breast substance is found to be studded with small raised points and some of these knobs may be the centres of tender spots. Often the axillary lymph glands are also found to be somewhat enlarged and tender though they remain soft in consistency, unlike the lymph glands associated with carcinoma.

The pain, tenderness and glandular enlargement all suggest that the breast is the seat of an inflammatory lesion and this interpretation is implied by the name that is given to it. Surgical teaching is however, commonly somewhat reticent with regard to the further details of the condition and to its etiology. The inquiring student is given to understand that there are three types of mastitis (1) *Chronic interstitial or lobular*, (2) *Chronic lobular*, and (3) *Chronic parenchymatous mastitis* and knowing that most inflammations are due to the action of pyogenic bacteria he assumes that some 'sub-acute' infection is here responsible. He has probably also seen cases of

abscess in the breast following lactation, and knows that then there is a definite infection, usually with the *S. pyogenes aureus*. The two conditions thus become connected in his mind and he perhaps imagines that the chronic condition is sometimes an aftermath of the acute. He is thus confounded in the bacterial interpretation of chronic mastitis, though he finds later that this knowledge gives him but little help in treating the disease.

Afterwards as clinical experience accumulates, the former student whose mental processes we are examining notices that there is in fact no connection between chronic and acute mastitis. The suppurative lesion is almost restricted to the period of lactation, whereas the chronic condition occurs at all ages and is perhaps commonest in women who have never borne children. Certainly an acute mastitis cannot be shown to be a predisposing cause of chronic mastitis. Clinical observation still affords no help in distinguishing between the interstitial and parenchymatous varieties nor are any of the ordinary clinical signs of bacterial infection to be found. The condition is not one which is dangerous to life and usually does not amount to more than discomfort in the sufferer. A woman who complains that her life is made miserable by it is apt to be classed as neurasthenic, and palliative treatment is given to the others.

But if chronic mastitis be not bacterial in origin what is it? If it is an insidious change taking place independently of any acute infection in the breast when and where are its obscure beginnings? If the terms 'interstitial' and 'parenchymatous' indicate merely academic subdivisions of one condition what then are the exact changes to be seen under the microscope and what is their relative importance? Is chronic mastitis really a clinical entity at all and if not, what is its relation to other diseased conditions of the breast? Lastly, if a true understanding of the condition is not of great intrinsic importance may it perhaps have some bearing on the vastly important question of the cause and prevention of cancer of the breast? These are the pathological problems that present themselves.

THE PLAN OF THE PRESENT INVESTIGATION

The investigation of chronic mastitis which I have recently attempted was undertaken at the suggestion of Professor G. E. Gask, and was carried out in the laboratories attached to the Surgical Professorial Unit at St Bartholomew's Hospital. It was proposed that a mammary gland should be removed from every female patient that came into the post-mortem room at the hospital during a given period and that it should be submitted to a careful macroscopic and microscopic examination. It was hoped that some information would thus be obtained concerning the early stages of pathological changes in the breast and as to the average age at which they become apparent. It was felt too that the investigation would also help to establish, at any rate in our own minds, a clear idea of the detailed histology of the condition. The material obtained from this source has provided the bulk of the results which are recorded here.

At the same time I have tried to investigate three other series of specimens firstly, some male mammary glands collected at random in the

post-mortem room secondly material removed from female patients operated upon for the grossest degrees of clinical chronic mastitis, thirdly mammary glands removed for carcinoma

Clearly the post-mortem room material would afford no cultural information as to the bacterial origin of the disease, but would be entirely histological in its bearings. On the other hand, the material obtained at operation would afford histological evidence of the later stages of the disease and could be tested bacteriologically.

The pathological material thus obtained has been hardened in 10 per cent formalin. Each breast has then been cut into serial slices carefully examined with the naked eye and portions have been selected for microscopic examination. I am aware that at the present time it is considered in some quarters that the only satisfactory way of examining a breast is by means of the large-scale or 'window-pane' sections of the whole gland and the method I have used has been somewhat contemptuously designated 'the cheese-tasting method'. I agree that large-scale sections would be the ideal, but the technical difficulty of making large numbers of these preparations has deterred me, and the expense of the apparatus that is needed has proved prohibitive. I would also submit that sections of a relatively small size give more accurate histological detail than the best of sections made on the more grandiose plan, but I stand open to correction on this point.

Lastly I have had under observation as out-patients a certain number of women in whom chronic mastitis had been diagnosed but not of a degree requiring operation.

THE HISTOLOGICAL STRUCTURE OF THE NORMAL BREAST

At the outset of any investigation of this kind it is obviously necessary to have a clear conception of the histological structure of the normal organ but in the case of the mammary gland this is not so simple a matter as might be supposed. Changes, presumably pathological, proved to be so common that an absolutely normal adult organ was difficult to find. Also the gland is subjected to so many violent physiological changes that a great many different aspects are regarded as normal. An attempt, however, will be made briefly to describe the normal with regard to the life-history of the individual.

The mammary gland, developed early in foetal life from modified sweat glands, is at birth much the same in either sex. Of true glandular tissue there is little or none, the organ consisting of simple ducts, between twelve and twenty in number, converging to the nipple. These ducts are surrounded by a matrix of fibrous connective tissue, which forms for the breast throughout its career a stable supporting framework. In this condition illustrated in *Fig. 62*,* it remains through most of the years of childhood. As puberty makes itself felt, the breast is awakened to greater activity. The ducts begin to throw out lateral branches which in turn subdivide again and again and in this way a racemose gland is formed possessing an enormous number of small

* All the illustrations in this article have been prepared from drawings made by
Mr J. R. Ford

terminal acini. Each of the main ducts opening at the nipple forms as it were the stem of a tree, of which the terminal acini may be called the 'leaves', and each mammary tree so constituted occupies a so-called lobule of the breast—so-called, because each lobule is not a separate structure which can be distinguished in the living subject, but is rather a histological conception. Meanwhile as the branches grow, the connective-tissue matrix undergoes a corresponding increase in bulk, so that the glandular tissue is not as a rule to be found encroaching on the cellular tissues in the neighbourhood. It is this connective tissue which is largely responsible for the increase in size at this period. Most of it persists throughout life, even when the glandular tissue has begun to disappear and I think it is perhaps this *relative* increase in the

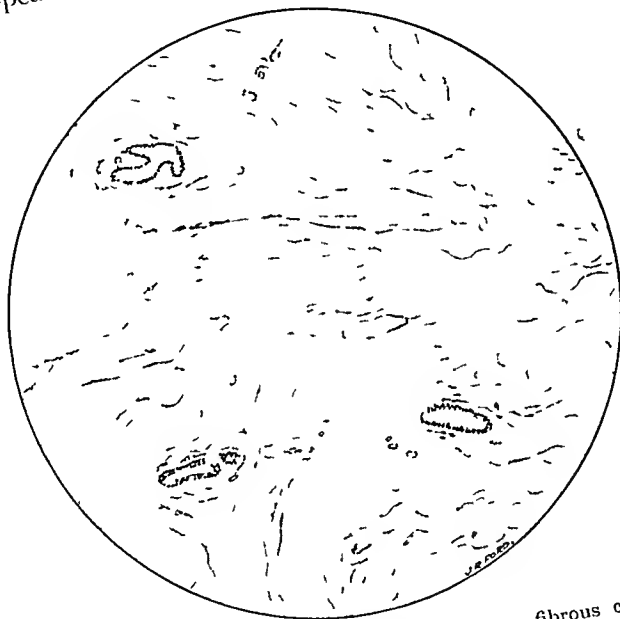


FIG. 62.—Immature breast* from a girl age 11 showing fibrous connective tissue and large ducts only ($\times 46$)

fibrous tissue which has sometimes given rise to a mistaken idea that an extensive pathological change, or fibrosis, has taken place. This will be referred to more fully later.

The epithelial lining of the mammary gland is, as has been said, derived from modified sweat glands—ultimately, that is to say, from squamous epithelium—and consists throughout of one layer of epithelial cells, beneath which is a layer of smaller more or less flattened supporting cells. In the main ducts the cells of the glandular layer are columnar or cylindrical in shape, and these give way as the ducts branch, to cells which are more definitely cubical. The transition from columnar to cubical is not abrupt, but very gradual, and it is difficult or impossible, to say where duct ends and acinus, or true secretory tissue begins. The truth is, I believe, that all the cells participate in the secretion, and the difference lies rather in the chemical

composition of the secretion than in their morphology. Even in the immature breast, which contains only the large collecting ducts, these ducts are filled with a fluid secretion.

I wish to draw attention to the relation of any group of acini in a normal adult breast to the surrounding connective tissue. It is evident that each group is surrounded by a rarefied form of connective tissue almost myxomatous in appearance (*Fig 63*), which is ready, as it were, to receive the enormous growth of gland which takes place before full functioning activity supervenes. This begins to be apparent even in the early months of pregnancy. The terminal acini multiply rapidly. Then lining epithelium swells and almost obliterates the lumen. Fat globules begin to appear in the inner parts of the cells, sometimes even in the cells of the main ducts. At this stage the masses of glandular tissue dominate the picture (*Fig 64*), and can be seen in sections with the naked eye. When lactation begins the inner half of the lining cells breaks down and is discharged into the lumen of the acini, the secretion so formed is forced by the pressure from behind of more secretion into the smaller ducts, and so to the main ducts and then exits in the nipple.



FIG 63 —Normal group of acini from the breast of a virgin, age 19 (< 60)



FIG 64 —Part of a group of acini undergoing normal hypertrophy of pregnancy shortly before the commencement of lactation (< 60)

So far nothing has been said of the modifications in shape which are seen in a duct as it passes from the surface of the nipple to the interior of the breast. These changes appear to me to be of great, though imperfectly appreciated importance in the pathology of the diseases of the breast. I wish to draw

particular attention to the manner in which the ducts open on the surface of the nipple. In the accompanying drawing (Fig 65) it will be seen that the actual mouth of the duct is a funnel-shaped structure lined with ordinary squamous epithelium. These squamous cells extend for a considerable distance below the surface of the nipple, and, in the inactive breast, at the point at which they end—that is, at the neck of the funnel—the lumen of the duct becomes extremely narrow and is usually almost obliterated. Immediately beyond this point there is an abrupt transition from squamous to columnar epithelium, and at the same time the duct suddenly opens out, the lumen becoming wider than at any other part of its course. This part forms the ampulla of anatomical nomenclature. The walls of the ampulla, unless it be greatly distended with secretion, are irregularly folded, and so it can adapt itself to wide variations in content.

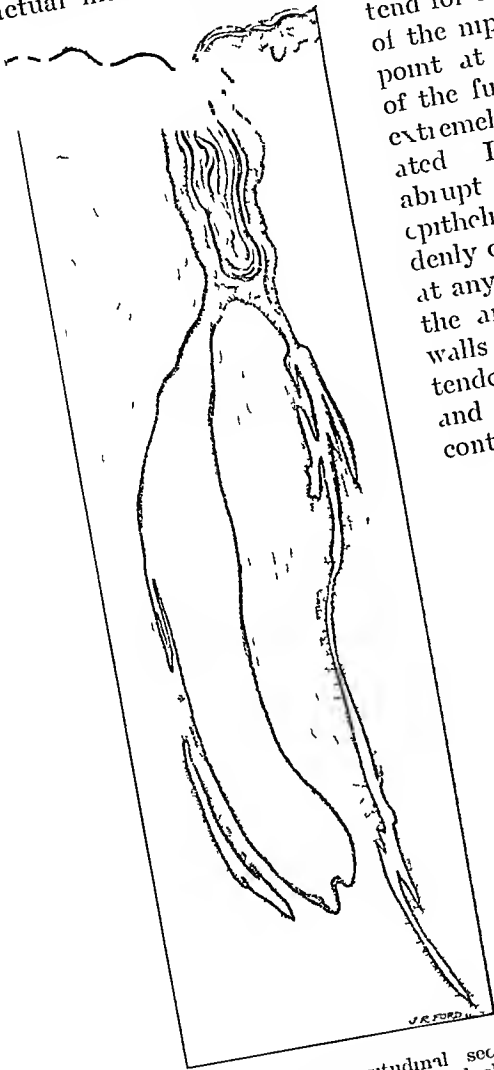


FIG 65—Longitudinal section of a duct mouth into which two collecting ducts open one being distended with secretion. The epithelial plug is shown in relation to the squamous celled lining of the mouth ($\times 20$).

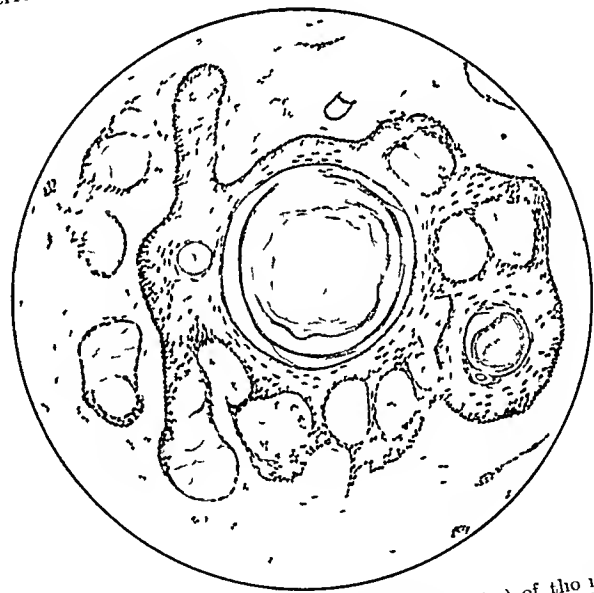


FIG 66—Transverse section (paraffin) of the mouth of a duct showing the laminated epithelial plug in position ($\times 100$).

A further point which I wish to emphasize is the fact that the funnel-shaped mouth of the duct is lined with an epithelium which normally keratinizes on the surface. These keratinized layers inevitably tend to accumulate in the depression formed by the funnel, and I have found that in the non-lactating breast the mouths of the ducts are, almost without exception,

filled by a laminated plug of keratinized epithelium. I have examined a very large number of nipples, both by making longitudinal sections and by serial transverse sections. In the longitudinal section (*Fig 65*) the plug can be seen to form a cone-shaped cast of the mouth of the duct. In a transverse section (*Fig 66*) the laminated plug is well seen, and it must be remembered

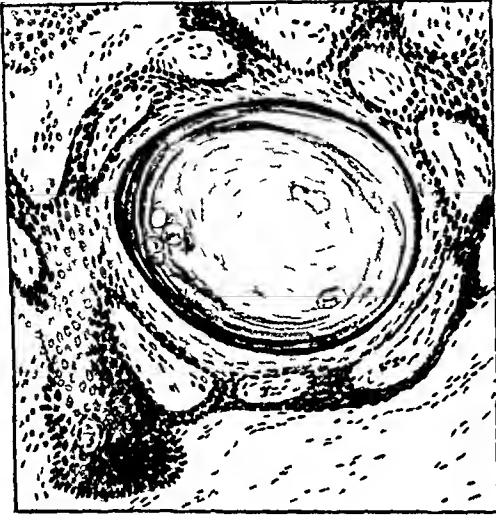


FIG 67—Near the surface showing laminated plug and sebaceous secretion



FIG 69—The narrowest part of the duct at the apex of the funnel. The lining cells are of transitional type



FIG 70—Just beyond *Fig 69*. The lumen still very narrow. The lining cells are definitely columnar

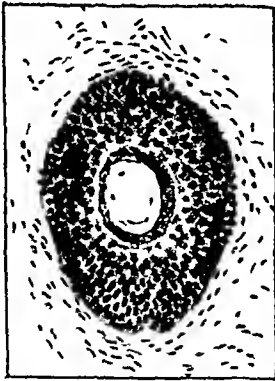


FIG 68—Further from the surface. The lumen is much smaller. The epithelial plug is still present

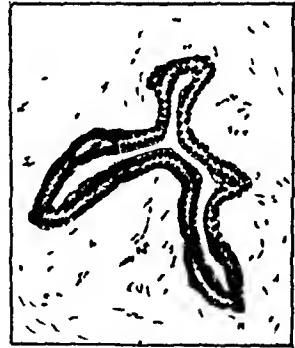


FIG 71—Immediately beyond *Fig 70*. The duct has opened out into the ampulla, with wide lumen and irregular outline

FIGS 58-62—TRANSVERSE SECTIONS SERIAL (FROZEN IN CYCLAM), OF THE MOUTH OF A DUCT ($\times 150$)

that this is drawn from a paraffin section in which the plug is somewhat shrunken. There are large sebaceous glands opening into the mouths of ducts close to the surface and the secretion of these has of course been dissolved out. In the above series of drawings (*Figs 67 to 71*) made from frozen sections stained with hematoxylin and Soudan III both laminated epithelium

and sebaceous secretion are well shown. As soon as the narrow neck of the funnel has been passed, the plug disappears and the duct opens out again, as has already been said.

The mouth of the duct in a lactating breast forms a striking contrast to this (Fig 72). The narrow neck is now widely open, and the epithelial plug, except for a few layers at the periphery, has disappeared. A transverse section taken through the narrowest part shows instead the secretion containing globules of fat lying in a lumen of considerable size (Fig 73).



FIG 72—Section of the nipple of a lactating breast showing the mouth of the duct opened up and the epithelial plug dislodged.

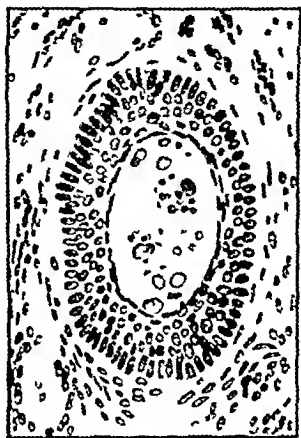


FIG 73—Transverse section (frozen in gelatin) through the narrowest part of the duct in a lactating breast. The lumen has opened out and is filled with secretion (haematoxylin and Soudan III) ($\times 165$).

Sections of the nipple also show the large amount of unstriped muscle tissue disposed rather irregularly in small bundles which this structure contains. The contraction of this muscle is presumably largely responsible for the narrow neck of the funnel. In any case it is clear that no secretion present in the ampullæ of a non-lactating breast is normally allowed to escape. The duct therefore becomes additionally sealed by a firm epithelial plug. This may be accentuated by the retraction or deformity of the nipples which is often found to be associated with chronic mastitis, and is by no means to be regarded as a sign diagnostic of carcinoma.

THE NORMAL PHYSIOLOGY OF THE BREAST

It may seem at first somewhat superfluous to devote a special section of a paper on the pathology of an organ to a consideration of its normal physiology, but in the case of the breast I believe the latter to be to a large extent the key to its pathology.

I have so far spoken of the breast as a gland either inactive or functioning

—that is, lactating, but I now wish to put forward the view that the breast is a gland which throughout life is exhibiting some secretory activity, the difference between a lactating and a non-lactating breast being one partly of degree and partly of the chemical constitution of the secretion.

The physiological history of the mammary gland begins at birth. It is well known that babies at birth often have a swelling of one or both breasts, and that sometimes a milky fluid may be expressed from the nipple. This may lead in some cases to a pyogenic infection of the breast possibly with some abscess formation, but there is little doubt that primarily there is an abortive attempt to fulfil its ultimate function of lactation. This may be called clinically an 'infancy mastitis', and is presumably to be explained by the fact that both foetal and maternal breasts are subjected to the same hormonal stimulus. I have no knowledge of the histological appearance in such a case, but I do know that in many of the sections of breasts of young children that I have seen the ducts are considerably distended with secretion, which may be taken as evidence that the cells of the immature gland have some functional activity.

The clinical condition of mastitis is not however, often seen in children between infancy and the age of 11 or 12, but from this time onwards the physiology of the breast is very intimately connected with that of the sexual glands. After the age of 11 in girls and 13 in boys the condition of 'puberty mastitis' is very commonly seen. There is a painful swelling of one or both breasts, which though not acute may persist in boys for two or three years and then disappear. In girls it passes into the phase of normal hypertrophy which attends the attainment of sexual maturity. Even in boys one or both breasts may undergo a similar hypertrophy at a considerably earlier age, producing the condition known as 'gynecomastia'. Occasionally such breasts have been removed, and histologically the appearance of the organ has been found to agree closely with that seen in the immature female breast, the ducts being well developed and distended with a clear secretion, though in two cases recently recorded¹ sections showed also that several of the changes characteristic of chronic mastitis were present.

In girls, with the arrival of sexual maturity the mammary glands enter upon a phase of permanent semi-activity, and are subjected to a constantly recurring physiological stimulation which is repeated in varying degrees at frequent intervals for a period of at least thirty-six years. At every menstrual period the glands are acted upon by hormones from the sexual glands, which awaken some sort of activity in the epithelial cells. In many women this may pass unnoticed. Many others are painfully conscious of the process and may be led to consult a doctor about it, who will perhaps make a diagnosis of 'chronic mastitis'. The condition should perhaps rather be called at first 'menstrual mastitis', though as time goes on the physiological state becomes more and more difficult to distinguish from the pathological. Apart from this it is possible that prolonged sexual excitement may stimulate the breast to such a degree that an actual secretion of milky fluid from the nipple is obtained.² This is the extreme example of the action of ovarian hormones.

In the event of pregnancy becoming established the menstrual cycle is for the time being abolished, and a different form of hormonal stimulation is

substituted. In response to this the cells enter upon their full functional activity and a period of enormous hypertrophy, culminating in lactation follows. Lactation is succeeded by a process of shrinkage, during which the cells of the hyperplastic gland largely disappear and are absorbed—unless further pregnancies follow in quick succession, in which case the gland may be almost continuously active for several years.

At about the age of 48 the possibility of further pregnancies comes to an end, but the phase of the climacteric may subject the mammary glands to a series of irregular hormone stimuli which only cease with the final establishment of the menopause. Then and then only, are these glands allowed to rest, and I believe that in strict normality an almost complete atrophy of glandular tissue gradually takes place. First the acini disappear, then the small ducts and finally only the largest collecting ducts remain. Even in these the cells are small, and the lumen greatly shrunken (*Fig 74*). The

connective-tissue framework may also become reduced in bulk, though the external appearance of the breast would often belie this owing to its becoming infiltrated with fat.

After the menopause therefore and in old age there is no true physiology of the breast to record but too often a physiological process has become merged in a pathological condition, which probably has had its origin many years before. A physiological stimulus may amount to a pathological insult if only it is repeated often enough.

It may be asked why I have chosen to dwell in such detail upon a series of physiological commonplace. My object has been to emphasize the fact that the epithelial cells of the breast are producing



FIG. 74.—Normal atrophy after the menopause. The acini are very shrunken and their lumen is almost obliterated ($\times 60$).

some sort of secretion almost continuously for many years. I have already demonstrated that, except during lactation, the mouths of the ducts are not normally patent and that no secretion can escape. The physiology of the breast entails, therefore, not merely secretory, but also continuous absorptive activity. I shall return later to the bearing of this upon the pathology of chronic mastitis.

THE HISTOLOGICAL EVIDENCE OF MASTITIS

I now turn to a description of the histological changes which I believe to be indicative of the presence of chronic mastitis. I can but describe each one in turn. It must be understood, however, that all may be seen at once in one small area though as a rule their relative distribution in the breast is very erratic.

If, as the name of the disease implies, it is an inflammatory condition, then it would be expected that one of the cardinal signs of inflammation,

infiltration of the connective tissues with leucocytes, would invariably be present. Actually, the presence of round cells is not an invariable sign, or at any rate, all parts of the diseased breast are not equally affected. In the earliest stages the infiltration is most commonly seen in the loose connective tissue immediately surrounding the groups of acini, but the cells are usually not at all densely packed. The presence of a few appears indeed, to be normal in the adult breast (Fig 63), and then number is always much increased in the lactating gland. In the later stages of mastitis the round cells tend to be concentrated at particular points



FIG 75—Acute stagnation mastitis in a breast already the seat of chronic mastitis. Inspissated milk can be seen apparently infiltrating the tissues in the centre and all the ducts and acini are distended with secretion. The nipple is retracted.



FIG 76—Acute stagnation mastitis, from the same specimen as Fig 75. Round-celled infiltration, fibrosis, and destruction of the epithelial lining ($\times 25$).

in close relation to dilated acini or along the course of ducts, but often it is not at all clear why groups of cells are present at one point and entirely absent in other places that are, to the eye equally, or even more affected by the disease.

It is however, evident that the round-celled reaction is more intense when the lumen of the acini or ducts that they surround is filled with a fluid rich in disintegrating cells or fat-containing secretion. The mere presence of epithelial changes certainly does not on the whole tend to determine a concentration of leucocytes. It is the presence of dead cells or inspissated secretion which attracts them most strongly. The microscopic appearances suggesting inflammation are therefore indirectly produced by interference with the escape of the products of epithelial activity from ducts and acini. The most extreme condition of leucocytic infiltration that I have found was in the breast of a woman who became pregnant after having developed an

advanced chronic mastitis. The breast (Fig 75) attempted to lactate but the secretion was unable to escape normally and reabsorption of the milk

was only effected with an intense inflammatory reaction which resulted in the destruction of the epithelial lining of many of the ducts with some surrounding fibrosis. The peculiar appearance produced is shown in Fig 76. A less acute effect is seen in Fig 77. In this case the patient, who was suffering from chronic mastitis, became pregnant but normal lactation hypertrophy did not take place the result being the appearance shown in the section. A similar condition, which may be called a 'stagnation mastitis', is seen clinically in a woman who has for some reason been compelled to cease suckling her child soon after its birth. Reabsorption of secretion is then attended by acute pain and inflammation which may initiate a chronic mastitis and give rise to considerable suffering in a subsequent pregnancy.

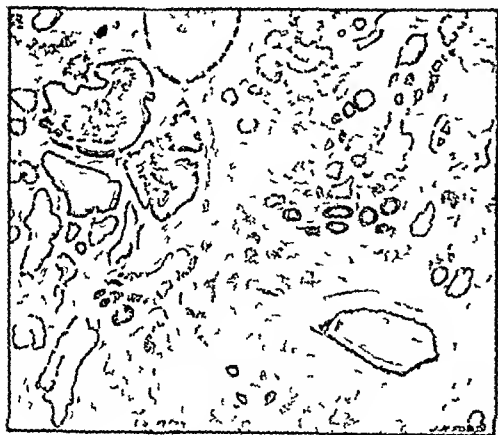


FIG 77—Attempted lactation in the presence of an advanced chronic mastitis. The acini have not developed normally. There is round celled infiltration, fibrosis and some epithelial proliferation. From a patient age 43 who died immediately after the birth of her first child. ($\times 60$)

It is important to note what type of cell is most commonly found, and it is clear that the lymphocyte nearly always predominates. In the extreme case mentioned there were also a good many polymorphonuclear cells and in another (Fig 95) there were large numbers of eosinophil cells, producing a very unusual appearance (Fig 78).

It is also possible by suitable staining to demonstrate in most cases a sprinkling of the so-called plasma cells outside the ducts and among the acini. These tend to be more numerous when the leucocytic infiltration is most marked, but it would be wrong to attach too much significance to their presence. They are probably the normal precursors of fibroblasts, and are concerned only in the production of the fibrosis next to be described.

The presence of fibrosis is another change seen in the interstitial tissues which is very capricious in its distribution. The word has, I suspect, been



FIG 78—Section from the breast shown in Fig 95. It is infiltrated with eosinophil cells. ($\times 300$)

used very loosely by some writers on the subject and sometimes the normal fibrous stroma has been mistaken for a pathological fibrosis owing to the alterations in the relative amounts of fibrous and glandular tissue. In the breasts of some women who have passed the menopause, glandular tissue has largely disappeared and only the larger ducts with a few groups of shrunken acini remain. These appear as oases in a desert of dense connective tissue but there has not necessarily been any fibrosis in the sense of replacement of glandular by fibrous tissue, or even any overgrowth thereof (*Fig 74*). When this does occur the histological appearance is characteristic.

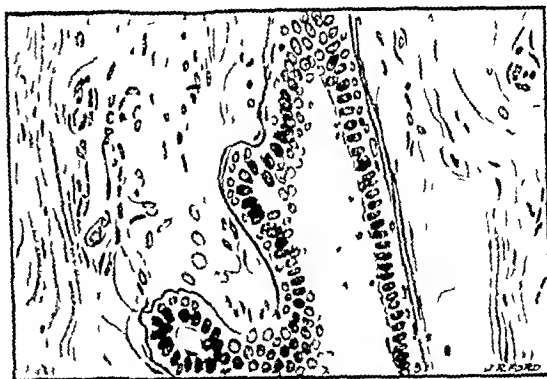


FIG 79—Fibrosis, early stage. Increase of fibrous connective tissue immediately outside the acini and ducts ($\times 210$)

Often the first evidence of true fibrosis is seen as an increase in the density of the layer of fibrous cells immediately outside the ducts or acini. In sections stained with eosin this is seen as a conspicuous red rim round these structures, consisting of several layers of connective-tissue cells. It is well shown in *Fig 79*.

In another form of fibrosis the area of loose and transparent connective tissue round the groups of acini tends to become contracted or to disappear altogether. The eosin staining then extends evenly right up to the acini (*Fig 80*). In a later stage the epithelial cells may disappear and be replaced entirely by fibrous tissue arranged as a group of small whorls, each whorl presumably representing an acinus. This appearance tends to resemble the arrangement of fibrous tissue seen in a fibro-adenoma intra-canalicular, and that, after all, is probably the late stage of an originally glandular tumour in which the fibrous tissue has be-

come predominant at the expense of the epithelial cells.

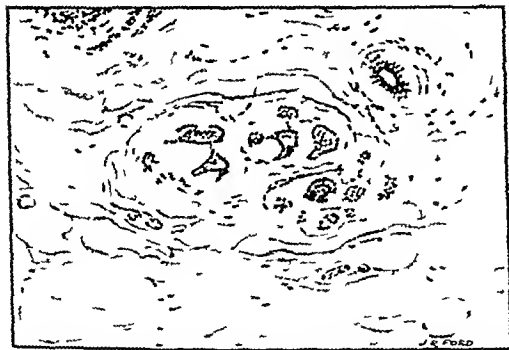


FIG 80—Fibrosis, later stage. Replacement of loose connective tissue with denser tissue (> 100)

Occasionally it may happen that there is an actual hypertrophy of fibrous tissue throughout the breast, and I have a specimen which consists chiefly of a large fibrous mass almost resembling a fibro-adenoma of unusual size (*Fig 81*). The other breast was the seat of a very advanced type of chronic mastitis with cysts and both were removed at operation. This massive fibrosis is however an unusual condition. Finney indeed says of it that it is "certainly extremely rare."

Dilatation of ducts and acini is a change that almost always accompanies chronic mastitis but it is difficult to judge at what point the process is to be regarded as pathological. For it is quite normal to find a dilatation of the large collecting ducts and ampullæ which can be seen with the naked eye when



FIG 81—Massive fibrosis of the breast

the breast is sliced and this is only to be expected in a secreting gland which has no outlet except when lactating (Fig 82). As the secretion accumulates this distention may be communicated to the smaller ducts and finally to the acini which normally have only a very small lumen, but clearly there is no criterion indicating definitely the point at which the process becomes patho-



FIG 82—Normal breast somewhat atrophied showing dilated collecting ducts

logical. I have therefore not been able to use any particular standard. Each section has been judged on its merits. The formation of small cysts which can be felt with the fingers is characteristic of chronic mastitis but this is only a more advanced stage of a change which can at first only be appreciated under the microscope. The presence of large cysts lined by flattened epithelium and filled with a clear greenish fluid, a turbid milky fluid, or a cheesy

mass is also characteristic of a still later stage of mastitis. These advanced changes are presumably associated with obstruction to a duct by fibrosis, cellular proliferation or pressure but I have not been able to demonstrate this in relation to any particular cyst.

The epithelial changes in chronic mastitis are more definite and more easily identified than those described so far. The changes appear to me to be of two different types. In one the change is primarily an enlargement

or swelling of the cells without very much active proliferation, in the other the cells do not always undergo any alteration in size, but simply proliferate in varying degrees forming either the 'laciform proliferation' so named by Sir Lenthal Cheate or 'massive proliferation' solid lumps or columns of cells filling and distending the spaces originally occupied by the acini or ducts in which the process arises. The first change may be partly degenerative but it is not connected with the so-called 'involution changes' seen in the breasts of women who have passed the menopause for I have found it at all ages from 16 upwards. Nor do the cells show any fatty changes in their cytoplasm when tested with the special fat stains. It seems on the other hand to be associated with some form of

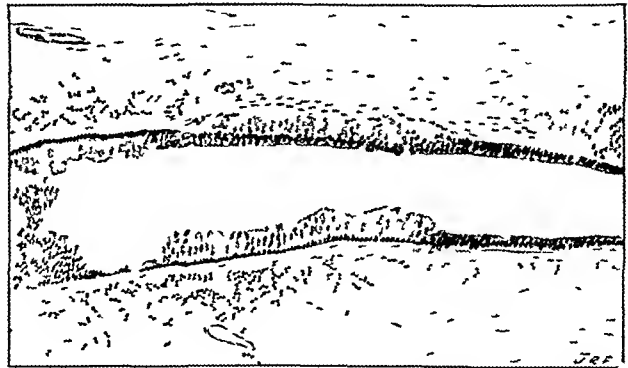


FIG 83—Longitudinal section of a duct. Swelling of epithelial cells in patches, with round celled infiltration outside ($\times 100$)

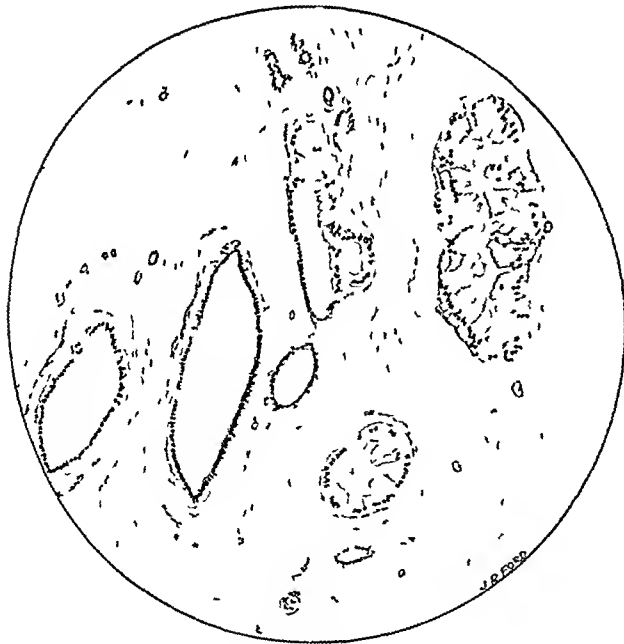


FIG 84—Swelling of epithelial cells in some of a group of acini and ducts. Distention of others ($\times 100$)

imitation, and may occur in patches. This is well seen in *Fig 83* where an early stage is illustrated in a longitudinal section of a duct. In certain places the normal low columnar cells have enlarged and become more than double their usual height. The lumen of the duct is at the same time somewhat distended, and outside the duct in relation to the altered cells is some degree of infiltration with round cells. Further stages of the same change are seen in *Figs 81* and *85*. In these sections, represented on a small and a large scale the change is clearly associated with ducts or acini which were already

distended, some showing the presence of secretion (*Fig 85*). This is nearly always found to be the case. In one duct (*Fig 81*) the cells are tending to disintegrate and it is possible that these changes may in some cases precede

the formation of a smooth-walled cyst lined with flattened cells representing the basal layer only and filled with milky fluid containing much cell debris but I have not been able definitely to connect these changes with the other

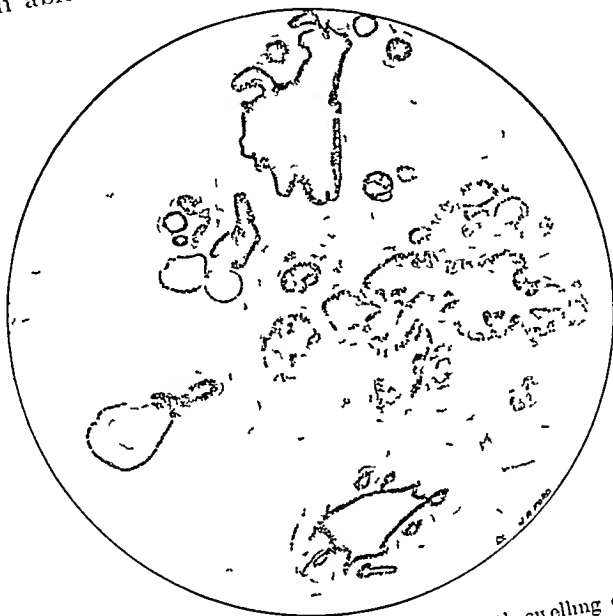


FIG 85 —Distention of a group of ducts and acini, with swelling of the epithelium in some ($\times 36$)

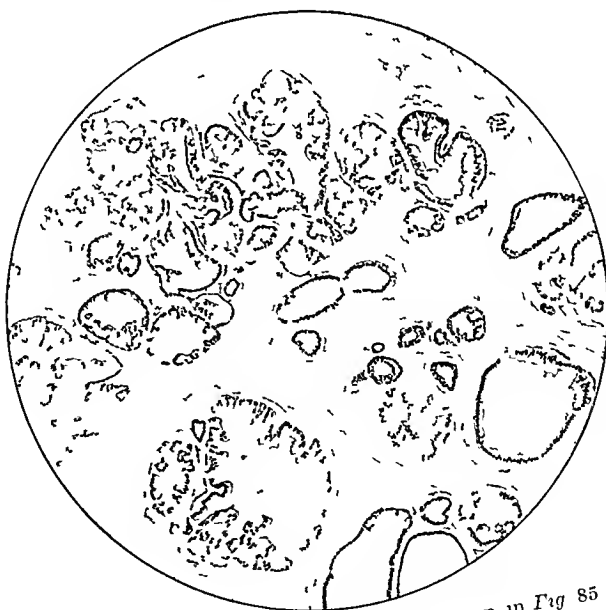


FIG 86 —A further degree of the same change as is seen in Fig 85. Apparently some proliferation ($\times 46$)

In most instances the change seems to spread and involve the glandular tissue of neighbouring groups, until the appearance seen in *Fig 86* is produced, or it may become even more striking than this. It is to be noticed in these three figures that there is no sign of a round-celled infiltration, but, as has already been pointed out, this change is very capricious, and its absence can occasion no surprise. The appearance of proliferation is in these sections probably due in most cases to oblique cutting of the irregularly swollen cells, but there does occasionally seem to be a true proliferation associated with it. The appearance in these sections is to be contrasted with that in *Fig 87*, which probably represents a true senile change, and was found in the breast of a woman of 70. The cells are here coalescing, and the nuclei have become very irregular in size

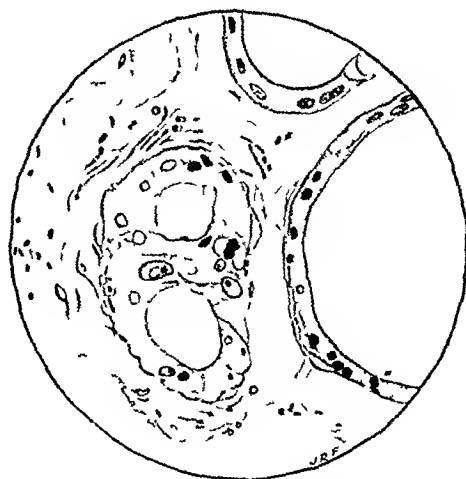


FIG 87—Section from a senile breast, most of which showed atrophy only. The cells are enlarged and are coalescing. The nuclei are very irregular in size and position.

The second type of cellular change is, as I have said, primarily a proliferative change and clearly indicates a much greater activity in the cells. An early stage of this is represented in *Fig 88*. Most of the ducts and acini



FIG 88—Irregular proliferation of epithelial cells with patches of round-celled infiltration. Some normal acini remain. ($\times 74$)

in neighbouring groups have been obliterated by the proliferation of their cells and in this instance the change is accompanied by a well-marked degree of round-celled infiltration in the neighbourhood. A single duct is seen on a

larger scale in Fig 89 Here, as proliferation proceeds, some of the cells are being cast off and will disintegrate When these have disappeared the laciform appearance will presumably result This is not in any essential particular different from the massive proliferation seen in Fig 90, where the outlines of a few acini can still be made out

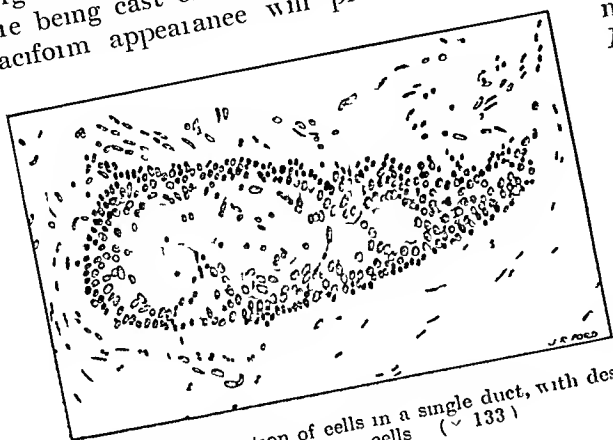


FIG 80—Proliferation of cells in a single duct, with desquamation of some cells ($\times 133$)

sprouting small excrescences all round its circumference shown in Fig 92 The excrescences are becoming more complex, in the upper part a large papillomatous growth is in process of formation

A large papilloma lies in a final stage is shown in Fig 93 A large papilloma lies in a smooth-walled cyst attached by a stalk at one point which is not seen in the section Such papillomata are commonly found in the ducts close to the nipple, and then presence often gives rise to a clear or blood-stained discharge from the nipple and this usually attracts the patient's attention But I do not believe that such a papilloma ever occurs as an isolated phenomenon The signs of chronic mastitis would certainly be found in other parts of the breast if search were made for them

I have now given some account of all the histological changes seen in chronic mastitis Summarized in as few words as possible, they are epithelial changes of two kinds, stages of the disease some degree of dilatation of the small ducts or acini, and a few patches of round cells

Another change which seems to be closely associated with the cellular changes already described takes place chiefly in the larger ducts and results in the formation of true papillomata The first stage of this is shown in Fig 91 where the wall of a distended duct is seen to be becoming more complex, and in the

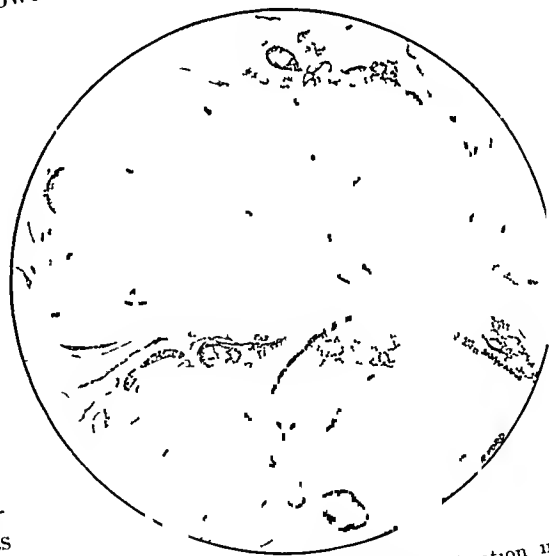


FIG 90—Massive epithelial proliferation in an advanced stage A few acini can still be seen ($\times 80$)

round-celled infiltration fibrosis, dilatation, and formation of papillomata In the early stages of the disease, as described here, some degree of fibrosis, and a few patches of round cells

are the chief histological evidences of its presence. In the later stages all these changes become accentuated and are associated with one or both of the forms of epithelial change. Sometimes the leucocytic activity appears not to be accentuated at this stage, but may, on the other hand, be almost absent. Numerous



FIG. 91.—First stage of the formation of papillomata in a duct. The epithelial cells are swollen. ($\times 74$)



FIG. 92.—Further stage in the formation of a papilloma. ($\times 44$)

'window-pane sections' would probably reveal their presence in certain places, but of this I cannot be sure. In the stage at which operation is performed, the slight dilatation has usually culminated in the formation of large cysts, but at this point the condition is given a number of different names indicating supposedly distinct diseases. This will be referred to again. The laciform or massive proliferation abundantly indicates that a profoundly abnormal activity has by some means been induced in the epithelial cells, and this may be of the greatest importance in considering the question of malignancy. This also will be discussed later.

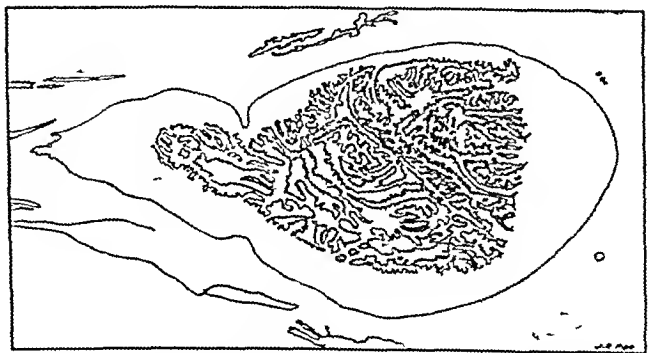


FIG. 93.—Fully formed papilloma lying in a smooth-walled cyst. The stalk is not seen in this section. ($\times 8$)

THE AGE AND SEX INCIDENCE OF PATHOLOGICAL CHANGES IN THE BREAST

One object of this investigation was to ascertain if possible at about what age the changes of chronic mastitis first became apparent. It is difficult, however, to obtain accurate facts from statistics based on the relatively small numbers to which I was necessarily limited. The post-mortem room material provided 116 specimens, of which 57 were normal and 59 showed inflammatory lesions. It would clearly be quite misleading to express the incidence of chronic mastitis as a percentage of the whole, since older patients would inevitably preponderate in material gathered from this source. I have therefore attempted to eliminate this, though only partially by taking the age of each case and showing in the accompanying diagram (Fig 94) the percentage,

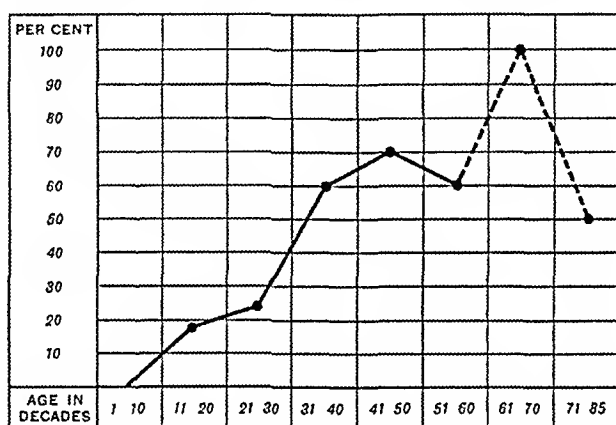


FIG 94—Chart showing age incidence of chronic mastitis

in every decade of individuals showing positive signs of chronic mastitis. It will be seen that the lesions first become apparent in the second decade, and rise to a maximum in women aged 40 to 50. It is of course possible that the figure of 18 per cent in the second decade would be lower if I had more material on which to base it. Also I feel quite sure that the extreme irregularities seen in the graph after the age of 60 are quite misleading, the number of cases beyond this age that were investigated being very small. I have therefore shown this part only in dotted lines. It is evident from this diagram that chronic mastitis is not a disease of the climacteric only, as has sometimes been supposed. It may have had its beginnings thirty years before this, though it is most apt to become clinically obvious at the later age.

The post-mortem room material also gives some indication of the influence of lactation upon the incidence of chronic mastitis. Details of family history had not been recorded in all cases but the figures as far as they could be ascertained were as follows —

POST-MORTEM ROOM MATERIAL

Average age of all positive cases, unmarried or childless	43 years
“ “ “ parous women	51 “
“ “ “	47 “

A similar impression is obtained from the series of cases which have developed manifestations of mastitis necessitating operation. The youngest unmarried patient in this series was 24. The youngest married patient was 46. The average ages were as follows —

OPERATION MATERIAL

Average age of unmarried patients	37 years
“ “ married patients	46 “
“ “ all patients	43 “

It seems to be clear that chronic mastitis tends to appear some *ten years* earlier in single women than in those who have borne children.

I have so far referred only to the incidence of chronic mastitis in the female sex. It is well known, however, that males may suffer from all the same affections of the mammary glands as females though very much less commonly. The early physiological types of inflammation in the breast, namely infancy and puberty mastitis occur almost as often in boys as in girls. Afterwards the breast in the male becomes quiescent. I need not here consider the condition known as ‘gynecomastia’, in which a boy, even before the period of puberty, develops a mammary appendage of the female type. In some cases this is more apparent than real, the hypertrophy being due chiefly to a local excess of fat. In others there is an actual development of immature glandular tissue resembling that of a girl. This, although abnormal, may be purely physiological and have no connection with mastitis. In later life, however, men may develop in their breasts all the same conditions as are seen in women. Ordinary chronic mastitis is not very rare in old men. Sometimes cysts, papillomata, and so forth are developed, and may necessitate operation. A definite percentage of cases of carcinoma of the breast is found in men. Many studies of the diseased conditions found in the male breast have been published,⁴ but these do not reveal any condition different from those found in women. I thought it worth while, therefore, to examine a series of male breasts from the post-mortem room, in order to find out how often the changes of chronic mastitis were to be found. I have examined 37 specimens and found some changes in 4 of them. In two cases there was localized epithelial proliferation only. In one there was fibrosis taking place in the wall of a dilated duct. In one from a man of 38 the picture was that of a well-developed chronic mastitis. Some of the ducts were enormously dilated and the secretion contained large numbers of cells. In some places there was swelling and desquamation of the epithelial cells and there were numerous patches of round-celled infiltration. The average age of the four patients was 54.

It was noticeable that almost every specimen showed that the ducts had a wide lumen and contained secretion so that the conditions very closely resemble those found in women. It must be remembered, however, that the gland tissue in the male is represented only by the largest collecting ducts. In the female breast the changes of mastitis are seldom seen in these large ducts but are almost always in the smaller ducts or acini which do not exist in the male. It may be therefore that the epithelium of the large ducts is for some reason less vulnerable and so less liable to pathological changes.

than that of the more truly glandular tissue. Perhaps it is partly to this that the male breast owes its comparative immunity from disease. It is also less subject to irregular hormonal stimuli.

THE THEORIES OF CAUSATION

As indicated at the beginning of this paper the idea of the causation of chronic mastitis that has commonly held the field is one involving the presence of some obscure bacterial infection. Sir Lenthal Cheate⁵ has indeed gone so far as to suggest that epithelial changes and even carcinoma itself, may be initiated by irritating foreign substances which have found their way into the breast through the openings in the nipple. Foreign substances so introduced can scarcely be supposed to be sterile, so that the conception again brings in the idea of direct bacterial infection from the outside. I cannot, however, discover any evidence in favour of the view that the inflammation is bacterial. All that I can gather seems to show that bacteria take no share in the disease.

I have shown I believe conclusively, that the normal breast has, except during lactation, no outlet through the nipple. The mouths of the ducts are mechanically closed a little way below the surface by muscular contraction which reduces the lumen almost to nothing. They are in addition sealed by a firm plug of epithelium, reinforced by sebaceous secretion, a substance which is known to be unfavourable to the growth of bacteria. It seems very unlikely, therefore, that any foreign substance could obtain entrance through the nipple. It cannot be claimed that lactation affords an opportunity for infection from without, since the changes of chronic mastitis are so often found in breasts which have never lactated.

There is the alternative supposition that bacteria may have been brought to the breast by the blood-stream. In the case of a tuberculous infection this undoubtedly happens, and presumably a pyogenic infection may occasionally occur in the breast in the course of a blood infection, as may happen in any other part of the body, but it is difficult to believe that every one of the vast number of women afflicted with chronic mastitis has pyogenic bacteria circulating in her blood in numbers large enough to produce a diffuse lesion in both breasts.

In either case it should be possible to recover these bacteria from a breast showing a well-marked degree of mastitis, but this I have failed to do. On many occasions I have made blood-broth cultures of breasts showing the changes of chronic mastitis, pieces of tissue having been taken from the breast with all aseptic precautions immediately after its removal from the body at operation. These have been incubated both aerobically and anaerobically. I have also made cultures of the fluid contents of cysts and of the milky fluid which can often be expressed from the dilated ducts of a breast showing chronic mastitis, a fluid which, obtained from cysts large or small is apt to be erroneously recorded as 'pus' without being further investigated. In no case has any growth of bacteria taken place—a result which an expert bacteriologist might be inclined to attribute to a failure on my part to find a suitable culture medium. This may be so, but further investigation must be left to the expert bacteriologist himself. These negative results are supported by the fact that I have never succeeded in demonstrating the presence of bacteria

by Gram's stain in sections of breast tissue or in the fluid contents of cysts. I may further point out that the histological appearances do not suggest the presence of bacteria. Bacterial infection is almost invariably accompanied by a leucocytic reaction. This, as has been said, is often absent in chronic mastitis. Also the leucocyte characteristic of pyogenic infection is the polymorphonuclear cell. In chronic mastitis it is always the lymphocyte which is present almost to the exclusion of polymorphonuclear leucocytes. Nothing can be inferred from the presence in one case of large numbers of eosinophil leucocytes.

I have mentioned that enlargement of the axillary lymph glands is often associated with chronic mastitis, but this cannot be interpreted as necessarily indicating bacterial infection. Absorption of any toxic products, bacterial or non-bacterial, may produce signs of lymphadenitis in the glands draining the affected area.

It seems reasonable, therefore, to reject the bacterial theory of causation on the ground that there is no evidence to support it.

Another theory which has been advanced suggests that chronic mastitis may be caused by a general toxæmia, the source of the toxin being a site of bacterial activity in some part of the body. Thus, it was observed by C. B. Lockwood many years ago that the symptoms of an inflammatory tumour in the breast disappeared after the removal of a source of infection, such as an infective vaginitis. But this result would have to be obtained in a considerable number of cases, and full details as to the accompanying circumstances including the menstrual history would have to be recorded before this could be regarded as more than a coincidence.

More recently, affections of the mammary gland have been connected with intestinal toxæmia by W. S. Bambridge.⁷ This author recorded in 1921 a series of 25 patients in whom a 'lumpy condition' in one or both breasts appeared to be benefited by treatment of a co-existing intestinal stasis. It is possible that a condition of chronic intestinal toxæmia might influence both the secretory activity of the mammary epithelium and the physiological condition of the patient. From some of these patients however cysts or fibro-adenomata were removed by operation, and it is not clear whether improvement in the 'lumpy conditions' of their breasts which took place after short-enucleating operations upon the large intestine is to be regarded as an event *post hoc* or *propter hoc*. Judgement as to the possible connection between chronic mastitis and chronic toxæmia must be suspended until more precise evidence is forthcoming.

Another condition which has been held by many writers to be responsible for chronic mastitis is one that is termed 'involution changes' but this is a phrase which in this connection does not convey any very clear meaning to my mind.

Involution is a word which presumably implies a folding up of something and as applied to a breast is most properly used when the hypertrophied organ begins to decrease in size and activity at the end of lactation. This change is probably a passive one in most respects, and according to the most recent views results partly from a lessened blood-supply and partly from the pressure produced by the secretion which is no longer removed as it is formed.

This effect may be aided by bandaging. Under these conditions the epithelial cells undergo autolysis or self-digestion, the products of this metabolism being then removed by way of the lymph- or blood-stream. In this way the hypertrophied organ is removed piecemeal in a relatively short time until nothing but the ducts with their normal proportion of branches and acini remain. It is difficult to see how any abnormal cellular processes could be initiated in this manner.

It is often stated also that involution changes take place at the menopause, and this statement is associated with the quite erroneous dictum that chronic mastitis is 'a disease of the climacteric'. It is true that the symptoms of the disease are clinically most obvious at that time because the cause of the mastitis whatever it may be has by then been in operation for a number of years and also because the breast is at that time being subjected to very irregular hormone stimuli. The disease must in all cases have begun many years before this and I see no justification whatever for supposing that the 'involution changes' attending the menopause have any connection with the disease. Moreover, these so-called involution changes are as I have so often seen them under the microscope usually nothing more than a simple atrophy. After the menopause the epithelial cells are no longer subjected to any hormone stimulus, the blood-supply tends to become smaller and the acini in consequence undergo a progressive shrinkage (*Fig 74*). In a breast which has not developed any marked degree of chronic mastitis with cyst formation or abnormal epithelial activity the acini become smaller and smaller, the lesser ducts tend almost to lose their lumen, and finally most of the glandular lobules disappear altogether. The large ducts always remain, and usually contain secretion, but except for these, a normal senile breast consists almost exclusively of fibrous connective tissue, which in stout subjects becomes infiltrated with large quantities of fat. Abnormal epithelial changes may occasionally be seen in a senile breast which is in most respects normal, and an example of this has been already illustrated (*Fig 87*), but my interpretation of the appearance is only tentative.

There does not seem therefore to be much evidence in favour of the involution theory of chronic mastitis and I think it should be abandoned.

Finally, it has been suggested that trauma may have some influence in initiating a chronic mastitis. I have shown, however, that the changes seen in this disease are diffuse, and clinical experience teaches that the condition is very often bilateral. It is further difficult to suppose that any woman could pass forty years of her existence without being subjected to the ordinary accidents of everyday life so that a history of trauma can always be obtained by questioning closely enough. Trauma is, in fact, so vague a factor that I do not think it need be further considered.

THE CAUSE OF MASTITIS TO BE FOUND IN PHYSIOLOGICAL PROCESSES IN THE BREAST

My consideration of the possible causes of chronic mastitis has been so far purely destructive. I now wish to offer a constructive solution of the problem which is, however, not yet susceptible of proof. Causes outside the breast do not seem to offer any real help. May there be then any cause within

the breast itself? I think the answer to this question is that there may indeed be a cause within the breast arising in the first place from an inherent defect in its anatomical construction, which reacts in its turn upon the normal physiological mechanisms.

It has already been demonstrated that the non-lactating breast is an organ which is subjected to continual physiological stimuli, but which has no outlet for the products of its own activity. A reabsorption of secretion must therefore continually be taking place. In addition to this the epithelial lining of both ducts and acini is being constantly renewed and effete cells are being cast off into the lumina. These cells disintegrate and must somehow be removed unless the breast is to become a stagnating mass of epithelial debris.

All the available evidence seems to me to point to the fact that the breast is itself continually pouring into the lumen of its ducts and acini a possible source of irritation to which all the pathological changes that I have reviewed may be attributed. If there should be a partial failure in the process of reabsorption of fluid and scavenging of epithelial debris, then any such irritation will become accentuated. This in its turn will further interfere with absorption and may initiate abnormal cellular activity, and so a vicious circle will become established.

I do not pretend to be able to suggest exactly what factors in the body may disturb the physiological balance of secretion and reabsorption. In some individuals the balance may be maintained throughout life. In others—probably the majority—it is upset after being successfully maintained for a considerable number of years, even then there are very wide variations in the degree of irritation produced and this variation occurs not only as between individuals but also in different parts of the same breast. The variation may be both in the concentration of the irritants formed in the secretions and in the susceptibility of the cells exposed to its action. The reaction of one individual may lie chiefly in the direction of fibrosis, in another it may produce the various forms of abnormal epithelial activity which have already been illustrated. In one case the results of irritation may become apparent after it has been acting for a relatively short time, in another it may be thirty or forty years before any pathological change can be appreciated. But whatever the source of irritation may be, it is clear that the time factor is of great importance. It has been very commonly observed that an advanced degree of chronic mastitis is seen at an earlier age in women who have never borne children than in women who have passed through the healthful process of pregnancy and lactation and this is confirmed by the figures already recorded. The explanation of this is to be found in the fact that during lactation the mouths of the mammary glands become unsealed and the products of activity are removed. If a woman has a large family of children this natural drainage is established with intermissions for a period of many years and only as middle age approaches do the breasts again begin to feed upon themselves. For this reason chronic mastitis has been called a disease of the climacteric but the condition really had its first beginnings when lactation ceased for the last time perhaps ten years before.

It should be possible to test the validity of this reasoning by examining the conditions found in the mammary glands of some other animal such as

the cow, which is normally lactating throughout its life after sexual maturity has been attained. I have been unable to find in text-books of veterinary science any reference to mastitis in a cow other than the acute infective form, and this is what the hypothesis requires. It is difficult to test the converse of this, that is, to investigate the conditions present in the inactive state, for the mammary gland of an elderly unmilked cow is not easily to be found. The determination of the incidence of chronic mastitis in cows may in fact be regarded as a hopeless quest.

It is worth remarking that recent investigation of the functions of the lymphocyte, the cell so characteristic of chronic mastitis, tends to confirm indirectly this interpretation of the source of irritation in the breast. The lymphocytes in chronic mastitis are, as has been said, very erratic in their distribution, but they are in maximum concentration in a lactating breast when there is any interference with the free escape of milk, and apart from lactation tend to be most numerous in relation to ducts or acini containing much cell debris or fatty secretion. This gains significance from the conclusion arrived at by Dr. S. Beigel⁹ that lymphocytes contain a lipase and are concerned in the digestion of fat and lecithin bodies both in physiological and pathological conditions. The presence and distribution of lymphocytes in the breast thus finds a natural explanation.

This hypothesis was first suggested to me by the observation that the non-lactating breast, though a secreting gland normally possesses no outlet. I revolved the idea for a long time in my mind and tested it in its different aspects before making any close investigation of what others had already written on the subject. When I did so I was interested to find that the same suggestion as to the effect of stagnating secretions in the breast had been made by Bertels¹⁰ in 1913 in the course of a discussion of the relation of chronic mastitis to carcinoma. Bertels' suggestion was quoted and amplified by Lukowsky¹¹ in 1921, but so far as I can discover the problem has not been examined in detail anywhere else. Binne's¹² view of the problem is cautious but suggestive. "Chronic cystic mastitis this pathological process impresses me as a reaction to some irritant. Microscopically and in addition to the parenchymatous changes, there is evidence of reaction in the stroma of the breast. No relation between this disease and any micro-organism has yet been established."

Many very suggestive observations are to be found in a valuable, though now almost unknown work published by Charles Creighton¹³ in 1878. Creighton had noticed that "the excessive production of the secretions of the breast, or their production out of season or their retention at or near their place of origin will be found to be among the chief factors in the causation of tumours of the breast." He had also noticed in sections of the breast of a ewe that was killed three weeks after giving birth to a dead lamb, and that had not been milked, the enormous number of lymphoid cells which were to be found "in the acini, in the spaces immediately outside them, and in the interlobular fibrous tissue." He further drew attention to the fact that the periodicity of the mammary gland is its earliest characteristic, and that this begins with its existence as a distinct organ. The first statement of the original law of periodicity he attributes to Shakespeare—"And so from hour

to hour we ripe and ripe, and then from hour to hour we rot and rot"¹⁴ His book contains other pregnant remarks too numerous to mention here

THE CHEMICAL PROBLEM

This explanation of the cause of chronic mastitis in the human being is based entirely on deductive reasoning, but a little thought will show that the hypothesis fits in with all the observed facts, both clinical and histological. It cannot, however, be finally accepted until the factor actually responsible for producing a state of irritation has been determined. This introduces an exceedingly difficult problem in biochemistry which can only be dealt with by those who have been specially trained in this line of investigation, and so far as I know little has been done as yet in this direction.

It can easily be demonstrated that there are wide variations in the composition of the fluid which is contained in cysts of the breast, or can be expressed from the cut surface of the gland. Commonly a clear green fluid is obtained, sometimes it is brown. Sometimes the fluid is turbid with cell debris, sometimes it is milky and contains both cell debris and fat globules. Occasionally the contents of the ducts or of a cyst are cheesy or almost solid



FIG 95—Chronic mastitis, with formation of cysts containing cheesy material. The breast was removed several years after the last pregnancy. It was infiltrated with eosinophil cells (*Fig 78*)

in consistency (*Fig 95*). This material may consist chiefly of enormous numbers of cast-off cells. Occasionally it may be composed almost entirely of fat and is then probably derived from inspissated milk. A cyst of this nature is known as a galactocele, and is likely to arise in a breast which has attempted to lactate in the presence of a mastitis already well established or of a carcinoma either condition causing an obstruction of one or more ducts.

I have collected the fluid from an ordinary smooth-walled cyst of the breast and found it to be strongly alkaline to litmus. Professor F. R. Fraser has, however, determined for me that its hydrogen-ion concentration is the same as is found in other body fluids. Investigations which may have some bearing on this problem have recently been recorded by W. Taylor.¹⁵ He has shown that milk contains in addition to its specific constituents various indigenous extractives such as amino-acids, urea, uric acid, creatin, and creatinin, all of which are to be regarded as excretory rather than as secretory products, the amounts varying with the degree of their concentration in the

blood But these observations are made only on the threshold of a gate to further knowledge

The chemical changes which may take place in these stagnating fluids are, as has been said, more or less unknown, but I feel sure that much will be learnt from the investigation of the chemistry of the secretions and of their effect upon the living cells that are exposed for a longer or a shorter time to their influence *

Attention has several times been drawn to the analogy between the changes that are found in middle age in the breast and in the prostate ¹⁶ and it is quite possible that chronic mastitis and senile hypertrophy of the prostate are dependent upon similar factors Light may also be thrown upon abnormal epithelial growth in other organs

THE RELATION OF MASTITIS TO OTHER NON-MALIGNANT DISEASES OF THE BREAST

The nomenclature of the various non-malignant affections of the mammary gland at present in use is confusing, and introduces many needless complications This seems to be due chiefly to a lack of appreciation of the essential continuity of so many of the non-malignant lesions found in the breast, separate names and descriptions having been applied to different phases of a chronic inflammatory condition as they were noticed so that the student is confronted with a series of lesions, each apparently a clinical entity Too much attention has been focused on the local manifestations and too little on the underlying cause I have already demonstrated the great frequency with which a chronic non-bacterial inflammation is met with in the breast This may be conveniently referred to as *chronic mastitis* and to this may be assigned the origin of many of the non-malignant lesions in the breast It cannot of course, be held responsible for causing the encapsulated tumours of the breast, such as the fibro-adenomata, which are true adenomata, and are as inexplicable as analogous tumours occurring in any other part of the body

Starting, therefore, with the chronic mastitis of the text-book, we find that an artificial distinction is made between *lobar* and *lobular* mastitis between *interstitial* and *parenchymatous* mastitis These distinctions depend only on the incidental distribution of the most obvious part of the lesion—most obvious, that is, to the fingers of the investigator—or on the kind of reaction, whether fibrous or epithelial, which happens to predominate in any given individual I have shown that a microscopic dilatation of ducts and acini is an early manifestation of chronic mastitis As this dilatation progresses small cystic spaces become isolated, and undergo progressive enlargement owing to the accumulation of fluid secretion They finally become evident to the touch, and if the lesion is diffuse the condition is called *chronic cystic mastitis*, *sero-cystic disease*, or *cystadenoma of Schimmelbusch* Often the lesion is more or less localized, and a single large cyst or a group of cysts results

* Since this was written further evidence has already appeared in the observations upon living cultures published by A. H. Drew (*Brit Jour Exper Pathol*, 1923, iv, 46), who has shown that cellular growth is stimulated by the presence of the products of autolysis of cells

These are described separately under the name of *simple cyst* of the breast but always the microscope reveals a diffuse condition of chronic mastitis in the neighbourhood of the large and obvious cyst. Often these cysts contain a clear fluid and the epithelium lining them is reduced to an inconspicuous layer of flattened cells. Such cysts have even been interpreted as dilatations of lymph spaces under the name of *interacinous cysts*¹⁷ of the breast. Sometimes pronounced epithelial changes occur in these cysts with the production of papillomatous growths inside their lumen. These are then described under the heading *papilliferous cysts*. If the papillomata happen to have grown chiefly in the large collecting ducts then a condition known as *duct papilloma* is diagnosed. The presence of a papilloma in the ampulla of the ducts often gives rise to a clear or blood stained discharge from the nipple and this has been interpreted as a clinical condition of some gravity¹⁸ but usually it denotes nothing more than this putrid manifestation of a chronic mastitis. The extreme degree of papillomatous growth within a cyst in which both cyst and papilloma are of large dimensions has been described under the name *Brodie's tumour*¹⁹ but this is seldom seen at the present time. A distinction is also made when the contents of the cyst consist chiefly of fat whether yellow or white in colour. This is formed from inspissated milk and may result from a 'stagnation mastitis' following lactation or attempted lactation in the presence of pre-existing mastitis. It is called a *galactocoele* but is not a common condition.

Various other names have been used by different writers. Bloodgood²⁰ has dubbed the isolated cyst containing clear fluid the 'blue-domed cyst', owing to the appearance it presents when the deep surface is exposed. This writer²¹ has also applied the name *semilobular parenchymatous hypertrophy* to the cystic form of chronic mastitis but I believe this implies an erroneous interpretation of its origin. He has also classified the different histological appearances seen in chronic mastitis under a great variety of complicated names some being even self-contradictory, such as 'non-encapsulated cystic adenoma'. This appears to be somewhat unnecessary. In considering chronic mastitis if the fundamental changes that may be found in epithelial and interstitial tissues are appreciated then the possible permutations and combinations of the changes may be assumed, and do not need special designations.

Although this section is headed "The relation of chronic mastitis to other non-malignant diseases of the breast", it is evident that I tend to regard most of the separately-named conditions as manifestations of chronic mastitis rather than as 'other diseases'. I do not, however, want to exaggerate this attempted simplification. There are other conditions in the breast, such as the *diffuse hypertrophy* sometimes seen in young women, which cannot be included in this category, and a number of other lesions, definitely infective or traumatic in origin, which I need not specify here.

THE RELATION OF MASTITIS TO CARCINOMA OF THE BREAST

The subject of the last section was mainly of academic interest. I now turn to a difficult subject of the greatest clinical and scientific importance. An immense body of literature has been devoted to the discussion of the relation between chronic mastitis and carcinoma of the breast. This seems to

begin with the statement made by Billroth²² in 1880 that "cancer does not develop in an otherwise normal breast" It culminates in the evidence published by McCarty²³ in 1915 the changes of chronic mastitis were present in every one of 967 cancerous breasts investigated by him The opinions of many other writers tend in the same direction, and it is indeed, an almost universally accepted idea that carcinoma of the breast is preceded by the epithelial changes of chronic mastitis McCarty claims that in chronic mastitis three distinct histological pictures are to be seen He distinguishes in the normal acinus of the breast two layers of cells—an inner layer of cubical secreting cells, and an outer layer of 'basket cells' which may be the precursors of the inner layer or only a supporting or nutritional layer He then describes in chronic mastitis (1) Hyperplasia of the outer layer, the inner layer intact, (2) Hyperplasia of the outer layer, the inner layer cast off and gone, (3) Hyperplasia of the outer layer with infiltration of the basal membrane which previously limited the cellular growth

Thus chronic mastitis has become carcinoma, and the trick is done It seems simple enough, but this interpretation of the histological appearances has not met with universal acceptance and the transition cannot yet be taken as proved More recently Sir Lenthal Cheate²⁴ in several valuable contributions has tried to demonstrate the same passage from innocent to malignant proliferation and has even been so bold as to class under the heading of 'the proemial breast' a mammary gland which shows the epithelial changes previously described But the cases which he has recorded under this designation appear to be fairly typical of an advanced stage of one variety of chronic mastitis, and it has been pointed out elsewhere²⁵ that carcinoma is seldom or never seen in diffuse cystic mastitis The appearances seen in such breasts certainly have been interpreted by some pathologists as actual carcinoma But that this is erroneous seems to be shown by the clinical history of such cases after operation All such patients are definitely cured by removal of the breast Recurrence never takes place, axillary glands are not invaded, and the condition does not behave in any respect as if it were malignant The absence of true histological infiltration agrees with this If definite infiltration with epithelial cells can be demonstrated, then cancer must be diagnosed But the co-existence of innocent and malignant proliferation does not prove that one necessarily precedes the other

However probable the occurrence of a 'precancerous' condition in chronic mastitis may appear it is exceedingly difficult to furnish any scientific proof of the change, and this has certainly not yet been done

It has already been mentioned that a great many writers have recorded their observations on the occurrence of chronic mastitis in cancerous breasts, and that McCarty found the association in every one of 967 breasts It may, in the face of this, seem futile to refer to my own observations, which have been made on only 25 specimens But even in this short series I have been struck with one or two facts In these 25 breasts I have found some evidence of chronic mastitis at a distance from the carcinoma in 20, that is 80 per cent Of the remaining 5, 3 had been infiltrated throughout with the carcinoma, and one was, in addition, lactating, so that it was not possible to form any opinion as to whether chronic mastitis had been associated with the carcinoma

or not. It seems to me very extraordinary that this same difficulty should not have occurred in McCarty's series of 967 specimens. The remaining 2 specimens of my series showed only a simple atrophy in the outlying parts of the breast. I was not therefore able to confirm the 100 per cent results of some observers.

Another singular fact that forced itself on my attention was that in most cases the breast tissue showed a great increase in epithelial activity close to the advancing edge of the carcinoma but that this was progressively less the greater the distance from the malignant infiltration. This proliferation, which resembles that seen in the proliferative type of chronic mastitis, looked as if it were in some way connected with the growth of the carcinoma in close proximity. The well-marked degree of infiltration with lymphocytes usually seen at the growing edge of the carcinoma indicated an inflammatory reaction and strongly suggested that the malignant cell might be influencing other cells at a distance by means of an abnormal and irritating secretion which induced a cellular proliferation similar to that resulting as I have suggested from long exposure to secretions in chronic mastitis, though acting very much more rapidly.* If this suggestion were to be substantiated it would explain the apparent association of chronic mastitis with carcinoma in so large a proportion of cases but it would in no way demonstrate that chronic mastitis is a 'precancerous' condition.

I cannot offer an opinion that would carry any weight as to the precise relation of chronic mastitis to carcinoma. I can only make the suggestion that carcinoma is not necessarily preceded by chronic mastitis but that both conditions or either separately may result from one cause—namely prolonged exposure to a chemical irritant such as may be present in the stagnating secretions of the breast. There is no reason for supposing that chemical irritation produces exactly the same reaction in the epithelial cells of different individuals. In some the cells appear to be more vulnerable than in others so that the effects are apparent at an earlier stage or the cellular proliferation tends to be of a malignant rather than of an innocent type. The factors governing the results are exceedingly obscure but it is noticeable that the time factor seems to have much the same influence in the incidence both of carcinoma and of chronic mastitis in its severer forms. Thus both are commonest a few years after the child-bearing period in married women, and occur rather earlier in unmarried women. There is a popular belief that to have a large number of children is the best way of avoiding cancer of the breast. This is in agreement with the hypothesis that is put forward here.

The proof that chemical irritation may produce a carcinoma of the breast has recently been furnished by experiments carried out in Tokio²⁶. Various forms of tar were injected at regular intervals into the mammary glands of mice. Carcinoma resulted in over 12 per cent of the experiments, so that the mammary gland epithelium has now been shown to respond to this particular chemical irritant in the same way as the epithelium of the skin. This was to be expected but it has now been established by experimental proof

* This suggestion tends to be confirmed by the experiments upon living cultures published by A. H. Drew (*loc cit.*) since the above was written. Malignant tumour cells have been shown to contain a substance which acts as a potent stimulus to cellular proliferation.

THE TREATMENT OF CHRONIC MASTITIS

In considering the treatment of chronic mastitis I shall not enlarge upon the operative methods of dealing with the more advanced stages of the disease. It is clear that in the present state of knowledge it is wisest to deal radically with the fully-developed type of chronic mastitis with cysts. Complete removal of the gland is necessary, though it may be remembered that, if there is no reason to suspect the presence of a carcinoma, there is no necessity for removing much, or even any, skin, and that a subareolar operation may be carried out without fear of recurrence. This may still be done even though the massive proliferation of epithelial cells is found to be present. If the disease is apparent as a single cyst or a localized group of cysts, then a local operation is adequate. Some diffuse change will almost certainly be present in the remainder of the breast, but it is always possible that this will not develop further and will not give rise to symptoms of any consequence. The same remarks may be applied to a papilloma of a duct-ampulla or to a galactoecele. Evacuation of a simple cyst by aspiration with a syringe is a palliative procedure, which is likely to be only temporary in its effect. A local operation is to be preferred.

The treatment of the earlier stages of chronic mastitis in which pain and tenderness, or merely discomfort, are the chief symptoms presents a more difficult problem. Often there is a psychological factor in the symptoms, and operation is scarcely ever to be advised. If the trouble is of the intermittent menstrual type no medical treatment or local application is likely to be of any avail. This type occurs chiefly in young women, and the symptoms may subside of themselves as the patient grows older. Otherwise marriage, followed by pregnancy and lactation, will relieve the patient of her trouble. The more persistent type of chronic mastitis in older patients I have attempted to treat in the way which is logically suggested by the investigations here described. I have first freed the mouths of the ducts in the nipple and opened up their natural outlets by bathing with hot water. Manual pressure combined with a suction bell will then often produce a considerable quantity of the turbid or clear green fluid which is always present in the ducts and dilated veins. The patient is instructed to carry out this treatment systematically, and in a few cases some relief of pain and discomfort has been obtained. But the results are disappointing on the whole. This is not unnatural, for the chronic inflammation has produced fibrosis and other abnormalities in the glandular system, so that efficient drainage of every lobule is no longer possible. The treatment should not be persisted in unless improvement very soon results.

The best results seem to be obtained by the judicious application of X rays. If the proper dosage is applied by an expert, a single treatment will usually have a most satisfactory effect. By this means the secretory activity of the epithelial cells is inhibited or destroyed, and the treatment is again the logical outcome of the interpretation I have put upon the pathology of the disease. The treatment is not new, having often been used empirically in the past, but I have here attempted to put it upon a rational basis.

CONCLUSIONS

1 The breast is a secreting gland which shows periodical activity from birth to the menopause

2 The normal non-lactating breast has no outlet through the nipple for the discharge of its secretions. Secretion must therefore be balanced normally by re-absorption

3 Chronic mastitis is manifested by dilatation of ducts and acini accumulation in them of the products of epithelial activity infiltration with lymphocytes fibrosis and epithelial changes. Distribution of all these is very erratic

4 Chronic mastitis is commonest in women but occurs also in men. It first appears in the second decade but is most often seen in the fifth. It appears earlier in single women than in women who have borne children

5 Chronic mastitis is not bacterial in origin toxic or traumatic, nor is it related to involution changes in the breast

6 The cause of chronic mastitis is probably to be found in chemical irritation due to stagnating secretions and epithelial debris. This cannot be proved until the chemical changes have been investigated

7 Chronic mastitis is the underlying cause of many lesions usually described as clinical entities such as simple cyst papilliferous cyst, or galactocele

8 Chronic mastitis though very often associated with carcinoma, has not been proved to be 'precancerous'. Both may be due to the same cause

9 Chronic mastitis in its more advanced stages must be treated by operation. At an earlier stage natural drainage may be tried or X rays may be applied

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CONGENITAL ILEOCÆCAL CYSTS

By H. F. MACAULEY, DUBLIN

THERE is a group of cases of intestinal cysts, with a very distinct pathology and definite symptomatology, which merits a place in surgical literature. Descriptions of individual cases of this group have appeared from time to time in the course of many years, but no attempt so far as I am aware, has been made to collect these cases, this is unfortunate as they form a group not only distinct and characteristic, but also of more than passing surgical interest. In this paper I add one more to their number and propose to collect and give a short account of all the other cases in such literature as is available.

The following is the history and its denouement in regard to my own case —

A baby girl of six months was brought to hospital with typical symptoms and signs of intussusception, and the usual 'tumour' was palpated, extending into the descending colon. Operation was undertaken immediately after admission, which was exactly twenty-four hours after the initial spasm of pain and associated vomiting was first noticed.

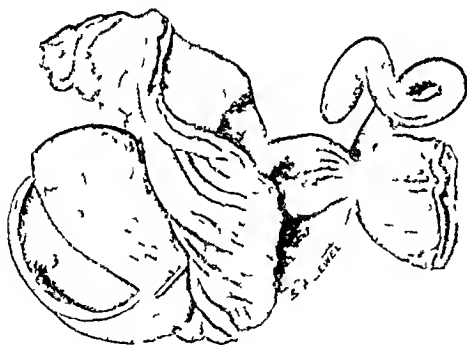


FIG. 96.—Showing the cyst projecting into the cæcum. (Natural size.)

It is noteworthy that the past history of the child was entirely negative as regards any gastro-intestinal complaint, with the exception of a short attack of 'colic' when the baby was six weeks old. The physique of the child, as is customary in cases of intussusception, was in every way excellent, and the baby had been nursed by the mother.

At operation, reduction even in its early stages was carried out with unusual difficulty for a case of this duration. When the 'tumour' had all been reduced except its terminal portion, the cæcum and adjacent ileum were brought outside the abdomen so that the final manipulation and appraisal of reduction could be carried out in full view. It was then that the unusual nature of the case was first noticed. To the eye it appeared that reduction was complete, for there was no fossa or peritoneal infolding around the entrance of what was the intussusception. Yet a hard knob-like structure could still be palpated in the interior of the cæcum on the site of the ileocæcal valve—apparently a portion of still unreduced bowel—and a finger could not be invaginated through the cæcal wall into the ileal lumen. A few further

gentle attempts were made to reduce the final mass but without success. The gut was then resected side-to-side anastomosis carried out and the child returned to bed. Six hours later however a fatal issue ensued due to post-operative shock.

Specimen—The resected gut was examined, and the explanation of the presence of a mass in the ileum while reduction was apparently complete was forthcoming. On incising the ileum and caecum a very definite thick-walled tense cyst was seen extended through the ileocecal valve.

The specimen was despatched to Professor Sir Arthur Keith to whom I am indebted for the report and is now in the Museum of the Royal College of Surgeons of England. The appended drawing (*Fig. 96*) gives a good idea of the actual specimen.

REPORT—A congenital cyst at the ileocecal junction which became intussuscepted within the caecum at the ileocecal angle. The cyst wall has the same coats as the small intestine, with interior quite cut off from the lumen of the bowel and yet lined with ordinary mucous membrane. I regard such as diverticular cysts arising by outgrowth from the embryonic bowel, but know no particular reason as to why they should arise at the ileocecal angle—(*Prof Sir A. Keith*)

OTHER CASES IN THE LITERATURE

The earliest description of a similar case was made by Frankel in 1882. Unfortunately a microscopic examination was not made but the autopsy findings and the age of the child are undoubted evidence that this was a case of congenital ileocecal cyst. At the autopsy on the child, who died on the third day after birth with symptoms of intestinal obstruction a cystic tumour was found at the termination of the ileum. The cyst was round, $2\frac{1}{2}$ cm. in diameter, and projected both into the ileum and caecum, and was only apparent after incising the bowel wall.

I have rejected an earlier case described by Conant² in 1856, as the evidence is insufficient for its inclusion. In this case a cystic tumour containing a thick, creamy semi-solid substance was found at autopsy in a male subject, it was attached to the ileum at its junction with the caecum. This may have been a broken-down tuberculous lymph gland.

However, a case described by Samsbury³ in 1886 is in a different category, and quite possibly truly belongs to the group under review though the author regarded it as of different nature. At autopsy on a girl of 11 years who had died of typhoid a large cyst was found in the interior of the colon, just above the ileocecal valve on the left. The cyst was entirely cut off from the bowel lumen, its wall was formed by the muscularis mucosae of the intestine, and in parts a distinct muscular wall was present, the interior of the cyst was smooth and apparently covered with a serous membrane. The author inclined to the view that the cyst arose from a sequestered portion of peritoneum, which gradually became distended by the exudation of fluid. He also suggested the possibility of the case being a mucous retention cyst or an enterocystoma. It is difficult to classify the case, but its position, the muscular structure of its wall, and the lining—which not improbably was ordinary

intestinal epithelium flattened by pressure—makes the diagnosis of enterocystoma very possible

As a contrast to these doubtful cases, a very definite one was recorded by Spiengel,⁴ which is very similar to my own case. It occurred in a girl of 15 years, and was the occasion of an intussusception. The cyst was in the wall of the ileum quite close to the ileocaecal valve. At operation the intussusception was irreducible and on examining the resected gut the cyst was found. The cyst wall was typical, an exact replica of the structure of the intestinal wall. This girl had suffered from periodical attacks of pain and vomiting since she was 4 years old. Probably the cyst was present since birth, but only became sufficiently large at the fourth year to encroach on the bowel lumen.

Two years later Hedinger⁵ described a case which occurred in a boy of 4 years. Here the cyst was very large, and filled a great part of the abdomen though it appeared to have originated in the ileocaecal region. Portions of the cyst wall showed typical intestinal structure all the layers being reproduced whereas in other parts the wall was only represented by connective tissue. The cyst was filled with lymph. The large size and contents of this cyst were apparently due to the rupture of a lymph vessel in the wall of the enlarging cyst. This child had been suffering from abdominal troubles for a long time previous to examination.

Ayer⁶ described a case in a man of 23 years, who was operated on for supposed appendicitis, with a severe attack of pain, vomiting, and constipation. These symptoms were present in a milder degree for years before operation. The case turned out to be a thick-walled cyst, about the size of a duck's egg in the caecum. Here, as so often is the case—even with the abdomen opened—the diagnosis was in doubt, and the case was thought at first to be an intussusception. Then the caecum was incised, and the cyst found overhanging the ileocaecal valve. There was no microscopic examination, but macroscopically the thick-walled cyst was apparently lined by mucous membrane. It is interesting to note that there was discovered at the site of the attachment of the cyst in this case a funnel-shaped diverticulum, which extended for about two inches between the layers of the mesentery and parallel with the ileum. The abnormal diverticulum in this case I would think due to the fact that the entire cyst was originally situated at the ileocaecal angle, but that owing to growth and intestinal movements the part of the cyst wall near the bowel was extruded into it, and hence the cyst became hourglass-shaped. Despite the absence of microscopic evidence, I believe this case is a genuine one of ileocaecal enterocyst—though the author, apparently on account of Dowd's⁷ teaching, attributed the case on slender evidence to a rest of the Wolffian body.

While in the cases previously described the cyst originated as a diverticulum from the small intestine and was lined by mucous membrane corresponding to that part of the intestinal tract, in a case described by Krogius⁸ the cyst arose as a diverticulum of the large bowel. The patient was a child of 2 months, and was operated on for intussusception. Here the site was the same, the ileocaecal angle, a well-developed muscular layer was also present, the epithelium was cylindrical, but contained numerous tubular glands. The

lumen of the bowel was narrowed by the growth which was as large as a pigeon's egg

In this category it is interesting to recall a case operated on by Baldwin⁹ where a diverticulum which contained all the coats of normal intestine was found at operation projecting from the cæcum at a point directly opposite to the entrance of the ileum

Blackader¹⁰ described a cyst which occurred exactly at the site of Baldwin's diverticulum. The usual findings appeared—a child of 10 weeks in this case a boy was brought to operation for intussusception. This turned out to be irreducible and the gut was then resected. Only when the incised intestine was examined did the true condition become manifest—a tense unilocular cyst being found situated in the wall of the cæcum opposite the ileocaecal valve and extending over and completely obstructing that orifice. The epithelium was columnar-celled and contained tubular glands and outside this the other intestinal layers were present. The case was diagnosed as retention cyst, but it was undoubtedly a case of enterocystoma.

The three following cases were all described in fairly recent English medical literature, and are all typical examples of the group of cases under discussion.

The first is described by Turner and Tipping¹¹. It occurred in a child of 4 months. The child had been in good health until a week before admission. During that week there were vague symptoms of irritability, followed on the day of admission by those of acute intussusception. Laparotomy was performed, and a tense cyst about one inch in diameter situated in the ileocaecal angle was found to encroach on the lumen of both the ileum and cæcum. The cyst wall was incised between the layers of the mesentery and much of the wall removed, the cut ends were stitched to the parietal peritoneum. A section made from the excised wall showed the structure of small intestine, with a lining of typical intestinal mucous membrane.

The second case was that of Ball,¹² and occurred in a child of 3 months. Symptoms of intestinal obstruction were present for two days previously. Again, even after laparotomy—as occurred in practically every case recorded—the condition was thought to be an irreducible intussusception. Here the colon was incised, and a tensely distended cyst was seen to project from the wall of the cæcum and block the ileocaecal orifice. Resection was then carried out. The inner layer of this cyst was formed of flattened epithelium, outside that was a layer composed of loose fibrous tissue and non-striated muscle.

The third case showed the cyst projected into the ileum, just on the ileal surface of the ileocaecal valve. The cyst, in the words of the authors, Bolton and Lawrence,¹³ “lay in the mesenteric aspect of the ileum between the layers of the mesentery, and the terminal ileum coursed over it.” The structure of the wall was a very complete reproduction of the intestine, even to the two distinct layers of smooth musculature. This specimen occurred in a baby girl of 3 months, who had suffered from gastro-intestinal complaints from birth, and was found at autopsy.

Only one other example remains, and it is that published and illustrated by Keith¹⁴. It possesses some features distinct from others. At autopsy in a new-born child a small ileocaecal cyst was found. In this instance the

cyst lay in the mesentery removed a little distance from both ileum and caecum. In other respects the case was typical and the cyst wall reproduced the intestinal structure. The cyst was small, and is interesting as occurring in such a young child showing what is probably the original site of these cysts before they have to change their position as a result of growth expansion.

SUMMARY

The group, as is apparent, is a very composite one.

1 The site of the cysts is very constant at the ileocaecal angle.

2 The symptoms are those of obstruction, and appear most frequently in the first six months after birth, but occasionally with a slow expansion of the cyst and a favourable position, may be delayed until adult life.

3 In childhood the cases are mostly frequently diagnosed intussusception, even after the abdominal wall is opened, and not infrequently an intussusception as in my own case, has been caused by the cyst.

The reason the ileocaecal angle should be a favourite place for these enterogenous cysts is entirely obscure. Formerly practically all intestinal cysts from the caecum to the jejunum whether on the convex or the concave surface of the intestinal loop, were attributed to Meckel's diverticulum, but this explanation is scarcely tenable for the latter especially when situated as low as the ileocaecal angle.

My thanks are due to Professor Keith for his report, and for help in facilitating my access to some of the literature.

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PATHOLOGICAL REMARKS ON SARCOMA OF THE LONG BONES

By PROFESSOR S. G. SHATTUCK, F.R.S.

THE following observations are confined to a few selected topics in relation to the above subject

Nomenclature —

Giant-celled Tumours of Bone — The innocent giant-celled tumour of bone is now generally known as a myeloma. A still better name, I have long thought would be 'giant-celled myeloma' implying that the elements of the bone-marrow concerned are particularly the multinucleated osteoclasts and not the myelocytes as in some forms of myelomatosis.

But at once we are confronted with the difficulty that some of the giant-celled tumours of bone are distinctly malignant and produce metastasis—a fact fully recognized by Sir Henry Butlin. How are such discrepancies to be reconciled?

The origin of giant-celled tumours in soft parts quite independently of bone is sometimes ignored. There are in the collection of general pathology in the Royal College of Surgeons, London, two examples of this. One is a tumour growing in the adductor muscles of the thigh, it is as large as the fist, and recurred after free removal. The microscopic sections of the neoplasm present in some places the features of spindle-celled sarcoma, and in others of myxosarcoma. Throughout the growth there are distributed considerable numbers of multinucleated giant cells. The second is a still larger primary tumour growing in the mesentery. It was removed together with a loop of the contiguous intestine, this tumour also recurred, and on subsequent exploration of the abdomen was found to have become insusceptible of further operation. Microscopic examination shows it to be spindle-celled, arising in lymphatic glands. Intermingled with the other elements there are large numbers of multinucleated giant cells.

Under the term myeloma, the simple giant-celled tumour of osteoclasts, and the true giant-celled sarcoma, have, it would appear, been included.

Endothelioma — This name is by some used in the most unmethodical manner. It should be limited to benign tumours arising from the endothelium of lymph spaces or blood-vessels. It is not our practice to give a common name to simple and malignant tumours, yet without compunction we accept such terms as benign and malignant endothelioma. If an endothelioma is malignant from the first or becomes so secondarily the best name for it, by far, is endothelial sarcoma. This is more illuminating than the older names of plexiform and alveolar sarcoma.

Infection of Lymphatic Glands —

There are two forms of sarcoma especially adapted to infect lymphatic glands secondarily—the lymphosarcoma and the endothelial sarcoma, of bone or elsewhere, the reason being that the tumour cells from the beginning lie in free connection with lymph radicles. Of lymphosarcoma of a long bone—i.e. a sarcoma of lymphatic tissue—I have seen but a single example of the lower end of the femur. Of endothelial sarcoma the most marked case I recall was an intact primary tumour infiltrating and replacing the head of the tibia in a man of 17. The limb was amputated. The growth when divided was highly alveolar to the naked eye its meshes being filled with large, flat polygonal cells. Death occurred from exhaustion. On dissection the popliteal and femoral (deep inguinal) lymphatic glands were found enlarged from secondary disease on the side of the primary tumour.

By reason of the necessary relationship between the tumour cells and the lymphatics it might at first be doubted if an endothelioma can be anything else than malignant. But in this connection we have to remember the essential biological difference that exists between the cells of benign and of malignant growths, as shown in spontaneously appearing tumours in mice: the benign tumour—e.g., adenoma of the mamma—does not admit of being grafted either into the same mouse or into others, whereas the malignant tumour—e.g., a squamous-celled carcinoma of the vulva—can be successfully grafted on the same or on other mice.

It is not the simple transference of elements then that suffices to produce metastatic growth, there is a profound difference in the biology of the simple and the malignant cell. When we know in what this consists we shall know the pathogenesis of malignant disease. Not the least tantalizing thing in regard to malignant growth is that one can see so clearly how it starts and how it progresses, without being able in the least to explain the why.

The Removal of Portions of Sarcoma for Histological Diagnosis —

This practice is at present widely condemned by surgeons and yet almost as widely resorted to. The removal is obviously accompanied with the opening of vessels and the displacement of tumour cells into or over their divided ends. The grossest instance of dissemination produced by exploration of a bone sarcoma of which I personally know was that of an osteoid tumour which surrounded the lower end of the shaft of the radius in a young man. The swelling was thought to be possibly syphilitic, or due to some form of necrosis accompanied with the formation of an involucrum. It was cut into and explored. A week afterwards an enlarged gland was felt at the elbow and another in the axilla, blood-stained fluid was withdrawn from the pleura, and within two months of the exploration death had occurred with metastases in both lungs.

Dry heat however, is, I find, a satisfactory means of tissue fixation. Excellent histological sections may be prepared from the thoroughly cooked muscle of roast mutton or from cubes cut out from kidney thoroughly cooked by frying. Heat is after all only a mode of coagulating the cell proteins, and fixing the tissue. In microscopic sections of roast mutton, stained with logwood and eosin, the striated muscle is well dyed with the latter and preserves its double striation, the nuclei of the sarcolemma are perfectly stained with

the hæmatoxvlin and so are those of the cells of the walls of the arterioles and of the general connective tissue even 'Miescher's cylinders' in some of the muscle fibres are quite well displayed, and so in the kidney *mutatis mutandis*. Then why not evade the danger by tying here?

With the technical aid of Messrs Allen and Hanbunys I have devised an electrically heated boier to remove a cylinder of tissue with a view of coagulating and killing it as the instrument is pressed forwards. The boier is heated by an element contained in its wall (which is double) the coil of which returns on itself and is connected at each end with a leading wire. The boier works in an outer double tube (the space in which is packed with asbestos) fitted to a centrally bored box-wood handle and is furnished with a plunger to push out the included cylinder of coagulated tissue from its cutting penetrating end.

In using any such boring instrument, the essential indication would be to penetrate the tumour very slowly, in order to coagulate and kill not only the tissue for microscopic examination within the boier, but also that immediately around it. One technical difficulty to overcome is to reduce the diameter of the boier to the required size. There seems to be no way of heating it by any mode of conduction from the proximal end, the inclusion of a coil in its wall involves some thickness, and corresponding increase in diameter, a boier not exceeding a quarter of an inch would be the maximum desirable. Another technical difficulty is the detachment of the cylinder of tissue. The coagulation would extend beyond the cutting edge in front, but how to disengage the cylinder of coagulated tissue without tearing through the uncoagulated?

The Rarity with which the Growth of Sarcoma follows Fracture of the Long Bones —

This is another subject worth reflection. I am personally acquainted with only one case. This was of a healthy policeman who was pushed violently against an iron railing and fractured the shaft of the humerus near its middle. The fracture healed normally and the splints were removed. A month and a half afterwards the patient noticed a nodule for the first time about the site of injury, this increased in size and was put down as excessive callus. As it continued to increase, sarcoma was diagnosed and the limb was amputated through the shoulder-joint. On dissection, a large tumour was found surrounding the site of fracture. And it is interesting to note that the tumour contained a conspicuous amount of cartilage, as though the cartilage of the callus had participated in the production of the chondrosarcoma. Death occurred two years later with pulmonary metastasis.

It is not that the fracture through the shaft of a long bone occurs through comparatively inert tissue—the adipose medulla and compact wall. What is commoner than transverse fracture of the patella? Yet the growth of sarcoma as a sequence is unknown. It is significant that the same is true of bone tuberculosis, it is not set a-going by fracture. It may be by contusion. The greater injury leads to the greater reaction, and to the local immunization by cells and body fluids against an extraneous factor.

Pathogenesis of Malignant Disease —

The foregoing considerations lead me to offer an hypothesis of the pathogenesis of human malignant disease which comprises three elements (1) That the agent is a filter-passing or ultramicroscopic virus, (2) That this is not a parasite, but is symbiotic, adsorbed to the cell-nucleus and cytoplasm—like a dye to filter paper, (3) That for the symbiosis the cell must be prepared. The preparation takes place usually by chronic inflammation—the great precursor of malignant disease.

Singly either the first or third factor is harmless so far as malignant growth is concerned. All three acting together, the biology of the cell is fundamentally changed, it is rendered independent of the rest of the body, which it continues to invade and ultimately leads to the death of the host of which it originally formed a normal part.

One is reminded of Paget's doctrine of the constitutional nature of malignant disease. Interpreted in a concrete form on such an hypothesis that which is 'transmitted' and is 'constitutional' would be the ultramicroscopic virus, from the parent to the offspring without producing any organic lesion in the unprepared placenta or any necessarily in the offspring, and even being passed on to a further generation until the prepared spot arises.

That what is transferred is not the malignant cell is clear from the fact that in cancerous stock the disease does not necessarily appear in the same organ, nor is it of the same histological kind. Indeed sarcoma may be intercalated amongst carcinomata. The filter-passing virus itself is indifferent or polyvalent. It is the prepared cell that determines the histological form of the disease. This is congruous, too, with the fact that independent and histologically different carcinomatous tumours may coexist in the same subject, or sarcoma may coexist with carcinoma. Nay, they may coexist in the same organ, as where a sarcoma of the myometrium grows alongside a carcinoma of the uterine mucosa.

The adsorption or symbiosis of a living ultramicroscopic virus with the cell may be responsible likewise for the abnormal mitosis so conspicuous in the cells of malignant growths, the normal division of the cell could hardly be else than upset under such circumstances.

THE NOMENCLATURE OF DISEASED STATES CAUSED BY CERTAIN VESTIGIAL STRUCTURES IN THE NECK

By J. ERNEST FRAZER LONDON

THIS is an effort to induce British clinicians to abandon certain terminologies which are inaccurate misleading and not sufficiently comprehensive, and to substitute for them a nomenclature or classification which has at any rate the virtue of being in accord with embryological facts and possibilities. The hoary legends of our youth still linger in corners of text-books of deservedly high reputation, but the pathetic interest with which we see them ought not to keep us from admitting the possibility of improving on them.

The particular conditions about which I am concerned at present are those which are lumped together under the distinguishing term 'branchial' or 'branchiogenetic'. These terms have been in use unworthily for many years past. 'Branchial cyst' is a common expression in the mouth of the student, and some say that 'branchial carcinoma' is not excessively rare in the neck of a patient.

It must be stated here at once that the question whether such a growth or such a cyst exists or does not exist is not of any importance at all from the present point of view. We are not concerned with that, but only with the provision of a better class-name under which if it occurs, it would fit naturally, and which it would not require if it does not occur. As a matter of fact, certain developmental vestiges in the neck undoubtedly give rise at times to certain pathological formations, so the necessity exists for an accurate and comprehensive nomenclature.

The objection to the use of the word 'branchial' in this connection lies in the fact that these things are not branchial in the strict sense, have nothing to do with branchiæ, and in many cases are outside the region which might be homologized with the pharyngeal arches that carry gills in the lowest vertebrates. Thus, even if the word be extended to take in the gill-bearing regions, it would still be inadequate and erroneous.

A better conception of the several conditions of this kind that may occur in the neck might surely be obtained by a terminology that puts them in a class with all other diseased vestigial structures in the body and allows of necessary subdivision and sub-classification enabling it to include all the possible pathological variations of these structures, in any part.

It is common knowledge that the pharynx of the human embryo possesses in its floor a series of *visceral arches*, with intervening *visceral grooves*—not clefts, as is often wrongly stated. Now these arches do not correspond to the branchial arches in fishes. the *third visceral* arch can be homologized with the *first branchial*, but the two visceral arches in front of this are not properly branchial. Many of the 'branchiogenetic' formations occur in front of the

region which really corresponds to the gill-bearing region of primitive fishes. Moreover, many others are really ectodermal in their origin and—for those who have a predilection for fishy nomenclature—might with a certain amount of propriety be termed ‘opercular’ or ‘sub-opercular’. But why do we in these cases leave the lines of classification that usually suffice in pathological matters and plunge into the sea after some primeval fish to find a label? These formations are not atavistic nor, it may be said, do they represent, as they come before the clinician any condition ever present in any normal animal—they are pathological changes occurring in vestiges of structures normally present in the human embryo and their label ought to show this. The human embryo never has and never had branchiæ. Morphologists believe that the visceral arches and grooves mark a phylogenetic memory of a branchiate stage in evolution, but the individual who possessed those appendages in a bygone time was not human but at best a tailed amphibian, or at a lower level a sort of mud-eel.

The objection that the ‘branchial’ label is inadequate is, however, of more direct force than that of its irrelevant opportunism when one is seeking to obtain a generally and universally applicable classification. It would perhaps, make the matter clearer if a short summary were given of the embryological facts concerned. Disregarding the complexities of the fourth pouch, we can say that each of the four visceral grooves—which lie behind their numbered arches—ends in a deep *lateral pouch* which is close to the surface, its lining ectoderm being in fact in contact with the surface ectoderm where this lies at the bottom of a corresponding *external groove*. The lateral pouches have *dorsal* and *ventral angles*, and the surface of contact with the ectoderm extends properly from one angle to the other. In the case of the first pouch, however, there is no definite lower angle, and the contact is only with the upturned dorsal angle. In the case of the second lateral pouch the distance between the angles increases rapidly, the upper angle and the pouch below it lose their contact with the ectoderm, and this is then only found in the region of the ventral angle. The upper or dorsal angle remains permanently in the middle ear, and the lower or ventral angle is placed in the tonsillar fossa. As the neck thickens, the 4th, 3rd and 2nd (ventral) angles retire from the general surface but carry with them their external contacts, in this way the external grooves corresponding to these pouches with the external arches between these grooves, all lined by ectoderm, are covered in by a hood or fold which grows over them from the dorsal aspect, extending from the 2nd arch in front to the pericardial region behind. Thus a recess lined by ectoderm is formed, at the bottom of which are the external arches and the external grooves which are connected with the internal pouches. This recess is the *cervical* or *pre-cervical sinus*. It is quickly covered in, its opening on the surface is closed, and it apparently disappears. It would be better, perhaps, to say that, like these other remnants, it is no longer to be recognized, and it will facilitate comprehension of the conditions if we imagine it still persisting in some obscure form. Then as the neck grows, the persisting sac will be drawn away from its close relation to the immediate wall of the pharynx, and its ectodermal contacts with the pouches will be drawn out into long cell-strands, which may contain a lumen, and can be termed *external pharyngeal ducts*, in contrast

with a similar but much less extensive—in human embryos—drawing out of the entodermal pouches which can be called *internal pharyngeal ducts*. Thus, if this system remained there would be three *internal* ducts drawn out from the pharynx at points corresponding to the developmental pouches and these ducts would be continuous through a solid intermedium (the closing plate) with three *external* ducts which would converge on a common cavity, the *cervical sinus*. The connection of this sinus with the surface is drawn out into a narrow tract and as a matter of fact, the external duct running from the region of the second pouch opens into this tract and not into the sinus.

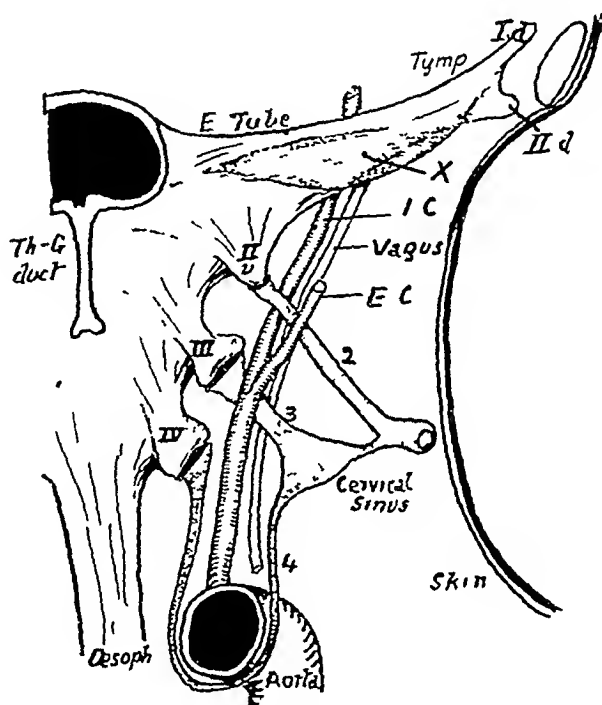


FIG. 97.—Schematic figure to show the vestigial structures in the neck with their relations to main arteries and nerves. The epithelial bodies are not represented.

Ia, II d, Dorsal angles of 1st and 2nd lateral pouches. *Ic, III, IV*, 'Internal pharyngeal ducts derived from ventral angles of 2nd, 3rd and 4th lateral pouches. *2, 3, 4*, External pharyngeal ducts derived from 2nd, 3rd, and 4th external grooves. *X*, Layer of entodermal cells cut off from lower part of Eustachian tube.

(Reproduced from a drawing by the Author.)

which therefore has only the external ducts from the 3rd and 4th pouch regions running into its deep aspect. A scheme of the arrangement is given in Fig. 97.

There seems to be no reason why any of these various and several structures should enlarge, and also no reason why any one of them should enlarge more than another. Mr. Hamilton Bailey, in his very interesting paper on "The Clinical Aspects of Branchial Cysts" in the April number of this JOURNAL, gives four types of the condition. His first type is one that I would feel disposed to refer to the elongated tract leading to the sinus, or to the 2nd external duct which runs into this tract. His second type seems to

point to enlargement of the sinus itself. The third should be referred, I think to enlargement of the 2nd external duct perhaps with more or less enlargement also of the sinus. I may remark in this connection that Mr Bailey, in quoting from me in this matter, has gathered a wrong impression of my statement regarding the relations to vessels and nerves. If he refers again to the paper he mentions he will find that I was speaking of 3rd pouch connections only, and am not in any way at variance with clinical experience. These relations will be considered later. The fourth type is a very interesting one to the embryologist for it may be the remnant of an internal duct, or possibly derived from one of the 'epithelial bodies' which are found in association with the pouches, or it is possibly, in spite of its epithelium, an ectodermal derivative, or one associated with the closing membrane.

These readings of the types given by Mr Hamilton Bailey are of course merely pious opinions of my own. There is only one way of settling the origin of any particular instance of an enlarged vestige and that is by detailed anatomical examination with reference to relations followed after removal by microscopic investigation. The question of anatomical relations has to do particularly with the connections with the pharynx and does not apply so much to derivatives of the sinus placed more superficially. The three pouches and their corresponding external ducts bear definite and distinct relations to the main vascular and nervous structures and *these relations, if the vessels are normal are absolutely fixed and certain*. The primary relations are shown in Fig. 97.

The 2nd external duct passes between the two carotids and in front of the vagus. The 3rd goes behind the common or internal carotid and in front of the vagus. The 4th is drawn down by the arch of the aorta on the left side, and by the subclavian on the right. These relations are facts, not theories and are absolutely fixed. If a duct goes behind the main artery and in front of the vagus, it is a remnant of the 3rd duct, but if it does not do so it is not a remnant of this duct. Similarly, the remnant of the 2nd goes between the two carotids to reach the pharynx. Any departure from this arrangement is not possible, if the vessels are normal. Whether or not any particular one of these structures may be enlarged is, as already stated beside the point but it may be said that (so far as I know) the only one that has been recognized with certainty is the 2nd, so far as the 4th is concerned, its course would seem to militate against its survival in any dangerous form. The cervical sinus is superficial to the vessels, and its opening is in front of the sternomastoid, drawn down to a low level in the neck. Fig. 97 shows how this opening may lead straight into a 2nd duct without necessarily involving the proper sinus at all. If the closing plate were perforated, it is conceivable that any of these ducts, if patent, might lead into the pharynx. The site of the 2nd pouch is at the tonsil, the 3rd at the pyriform fossa, and the 4th at the lower end of the pharynx. Of these, again a perforation has only been certainly recognized in the 2nd, but it is quite possible that it might exist without demonstration in the 3rd. The ectodermal derivatives might be expected to show a stratified cell-lining, and a columnar-celled layer would probably exist in any ectodermal prolongation. Finally, there develops in some lower mammals a 'superficial thymus' in association with the ectoderm of the sinus, and it may

be that the lymphadenoid tissue in the walls of cysts of the sinus (presumably) is really thymic. I have examined some sections of such cysts in which the thymic structure was more than strongly suggested and what looked like badly formed Hassall's corpuscles were distributed through the tissue.

The vestigial structures in this region, then, as shown in the diagram include entodermal processes of the 2nd, 3rd and 1st pouches, ectodermal ducts associated with the same pouches and a cervical sinus with its drawn-out channel of aperture. Mention has been made of other structures connected with these pouches derived from the 'epithelial bodies' of the pouches—these may possibly form small cysts—associated with the deep aspect of the thyroid gland or with the parathyroids, or in the upper part of the thorax—which should have their proper place in a complete nomenclature, but they are not represented in the diagram. Certain other structures are shown, however, which should also be included in any classification of vestiges here. One is the thyroglossal duct, about which it is not necessary to say more, as its occasional pathological persistence is well known. The other, labelled X in the diagram, is a double layer of entodermal cells which are cut off from the lower aspect of the Eustachian tube. I have described the occurrence of this in the third month, and it is the result of the same process which has separated the dorsal and ventral angles of the 2nd pouch—a forward growth from the 3rd arch destroys this portion of the 2nd pouch and comes up against the 1st groove, which is caught between it and the 1st arch. Morphologically the entodermal part thus caught may represent the lower angle and internal duct of the 1st pouch, and the result is that the first groove, in the tubal region, is wiped out of practical existence, for the opposed layers of entoderm seem quickly to disappear. But the possibility of their persistence is always there even if it has never occurred up to now, it may happen to-morrow but the only evidence against its occurrence is purely negative. Hence from the point of view of this paper, it must be included among the vestigial possibilities. If a cyst of such a vestige were present, it would lie below the tube, behind (at any rate in part) the tensor palati, and in front of the carotid and stylopharyngeus, and if by any chance it opened into the pharynx, it would do so through the sinus of Morgagni.

All these various potentialities for pathological activities, to my mind, call for classification under proper headings. The label 'branchial' only touches indirectly a small part of one of them, is doubtfully applied to another part, has really nothing to do with the rest of it, and is altogether lacking in association with the other vestiges. Even if one submitted to a piscine terminology for a human condition, that would leave the other conditions to be labelled separately. Surely it would be more correct to include all signs of pathological processes in such remnants under the general term *vestigial* in everyday use, in reference to some particular case, the qualifying term 'cervical', 'abdominal', or whatever it might be, would be dropped as unnecessary. Further subdivision would give us such distinguishing labels as might be convenient—terms such as median and lateral, superficial and deep, ectodermal and entodermal, or whatever word might be suitable, would aid in distinguishing any particular condition among the class of vestigial pathological states. Thus, a persistent and open canal of His would be properly

described as a median or paramedian vestigial entodermal sinus, although in everyday use the labels of 'canal of His' or 'thyroglossal duct' would probably be preferred as less cumbersome, and there are no objections other than general ones, to their use, the common 'branchial cyst' in the neck would become a lateral vestigial cyst, ectodermal or entodermal as the case might be, and could be more particularly distinguished if its developmental value admitted of definite demonstration a cystic distention of a persistent remnant of the first groove would be a right or left sub-tubal vestigial (entodermal) cyst the same idea in terminology would come in, with descriptive accuracy, in fistulæ or carcinoma or in any other condition associated with vestigial structures

I am afraid that I have written somewhat at length on what may be considered a matter of relatively small importance, but it seems to me that improper labelling is a fruitful source of mistaken ideas and a hindrance to a proper conception of the underlying facts, wherever it is employed I have tried to show that the word 'branchial' is inapplicable to most of the cases in which it is used definitely wrong in some of them and of doubtful value in the others I confess that I would like to see the word completely dropped from all writings on human anatomy or embryology A proper nomenclature should include under one heading and in one class the several affections which have their origin from vestigial persistence, in whatever part of the body they may occur, and should allow of rational sub-classification within this class

VISITS TO SURGICAL CLINICS AT HOME AND ABROAD

PROFESSOR PUTTI AND THE ISTITUTO ORTOPEDICO RIZZOLI AT BOLOGNA

THE Orthopædic Institute of which Professor Putti is Director owes its existence to the generosity and foresight of Rizzoli a general surgeon of Bologna, who left his whole fortune for the purpose of buying a large Olivetan monastery near the city converting it to its present purpose, and partially

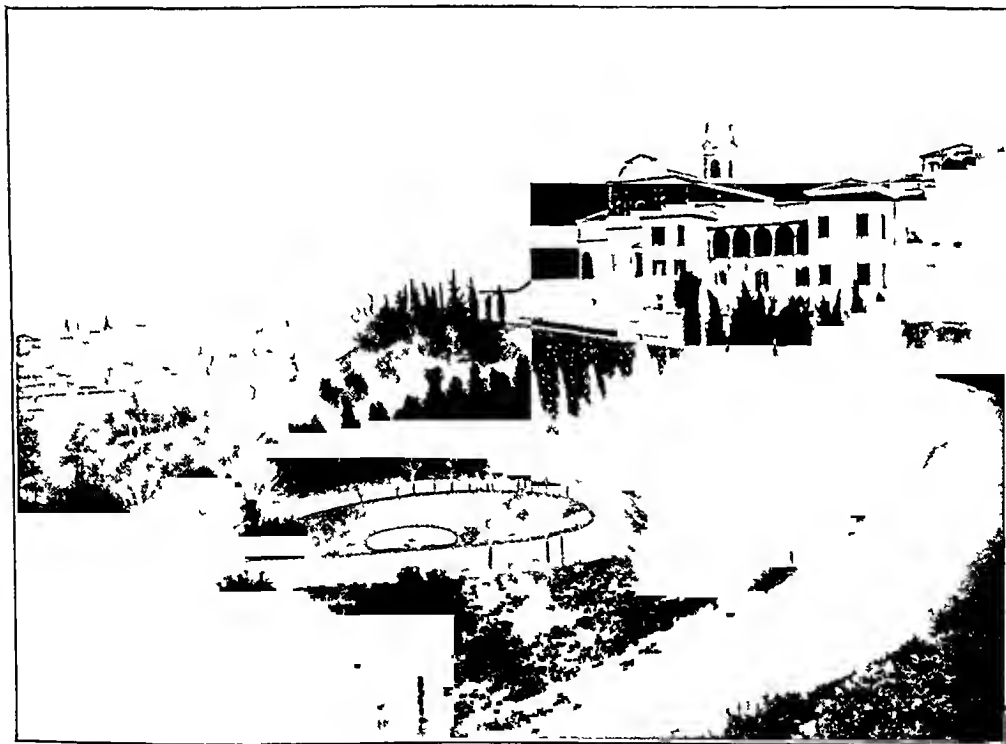


FIG. 98.—View from the Institute

endowing it. The Institute is situated on a high hill, about three-quarters' of a mile outside the city walls, and commands from its grounds and balconies a magnificent panorama of the city itself and the country for miles around (Fig. 98). To English readers the idea of a monastery conjures up visions of frowning walls and dark, depressing cells, but this fine old Italian monastery

is very different, the whole place is full of light and air and beauty and must serve as a constant inspiration to all who are privileged to work there. Much of the building is of polished marble, and the interior is lavishly adorned with frescoes and mural paintings whilst its architecture, though simple is conceived on a noble and effective plan.

The building has lent itself admirably to adaptation as a modern orthopedic hospital. A central corridor runs right through it, and houses on either side the administrative offices and the gymnasium. The wards are disposed to right and left of it, on two floors, arranged about large quadrangles which are planted out as sub-tropical gardens (*Fig 99*). The adult patients are nursed



FIG. 99.—View in one of the quadrangles.

for the most part in the original monastic cells which are rooms large enough to accommodate three or four beds, paying patients of the first grade, however, each have rooms to themselves. Children are housed in two large modern wards of the usual type, made by knocking down the partition-walls of a number of the monastic cells.

The hospital can accommodate about 200 in-patients, and these are of two kinds, free patients and contributory patients. The latter are of three grades: (1) Those who can only pay a moderate amount towards the total cost of their maintenance, (2) Those who pay just about as much as they cost, and (3) Those who pay freely. No distinction is made, as regards the general social amenities provided, between the various grades of contributing patients.

The general principle upon which the hospital is run is that then payments, added to the small endowment that was left over from Rizzoli's fortune after the building itself had been bought and adapted serve to maintain the free patients and to avoid constant appeals to the charitable public. There are, as a rule, about 50 free patients and 150 paying ones, it is found that these proportions are approximately correct in relation to the present economic conditions. Out-patients contribute being arranged in two grades according to their means, but they do not pay as much as they cost, a few who bring certificates of real poverty are treated entirely gratuitously. The cost of treatment is still high for the cost of living has not fallen in Italy since the War ended wages remain at the war-time level and consequently all commodities remain expensive.

The Director takes an active interest in the business side of his hospital, in addition to carrying out by far the largest share of the surgical work, in his central office he has large-scale graphs, which show all the important administrative data in a form in which they can be readily studied, these are kept hung on the walls all round the room. In this department, also are preserved the records of all the patients filed on the card-index system whilst every sub-department has its own registers and can supply details concerning any patient at a moment's notice. Considerable attention is paid to the keeping of good records and wherever possible these are made upon a uniform plan for instance, in all cases of polyomyelitis a special printed form is used on which all the important headings are set down. Full use is made of photography as an aid to accurate recording, almost every patient is photographed before and after treatment and prints and lantern slides are made from the negatives and filed according to subject so as to be immediately available for teaching purposes. For the recording of scoliosis Schultess' drawing apparatus is used, in conjunction with a special chart, whilst in many cases of talipes and the like plaster casts are taken and preserved in the museum. The conception and organization of the whole place are admirable and one recognizes everywhere evidence of the twofold function that the Institute has been designed to fulfil, viz, that of a curative hospital and of a centre for the study and teaching of orthopædic science. And this is surely very fitting, for the city of Bologna is the home of the oldest university in the world. Valsalva and Malpighi were amongst its former professors of anatomy, and the fine old oak-panelled room in which they taught is still shown to interested visitors to the University library, where it serves nowadays as a committee-room, there one may see the beautifully-carved life-size figures of the dissected human body with which the mediæval professors were wont to illustrate their lectures. Here also Tagliacozzi taught, and there is a quaint figure at the head of one of the wooden pillars of the room showing a little imp holding out a human nose towards the visitor.

The University of Bologna is still of considerable size and importance, it has over three thousand students. Dr. Putti is the Professor of Orthopædic Surgery, and gives regular clinical teaching to the undergraduates. At Bologna, Rome and Naples, medical students are required to attend compulsory courses in orthopædic surgery, though they are not yet required to pass any special examination in that subject.

In connection with the Istituto Rizzoli there is a very fine library, dedicated to King Umberto I. This magnificent room, which was originally the refectory of the monks, has its walls and roof decorated with beautiful mural paintings, its noble proportions and rich colouring make it one of the glories of the ancient city of Bologna. In this library are filed copies of all the leading orthopædic and general surgical periodicals of the world together with some 7400 theses, and there are over 7800 books of reference upon its shelves. Abstracts are prepared by the librarian, under the Professor's directions, of all the most important papers published, and these are filed and indexed in such a manner as to be readily available. The Director and his associates make considerable use of the library, we were told by one of the younger



FIG. 100.—One of the three gymnasia.

assistants that Professor Putti spent many hours there, studying the writings of foreign authors, or looking up the bibliography of any cases of unusual interest that might be in the wards. His lectures show a wide acquaintance with the work of others, as well as a wealth of personal observation and experience. The fullest possible use is made of all the clinical material available, and so efficient is the system of fact-recording, so fruitful the spirit of progress and research that infects all the workers, that it has recently been found possible to bring out a journal, six times a year, embodying the original papers that emanate from the Istituto. In this journal, entitled *La Chirurgia degli Organi di Movimento*, are also published abstracts of the leading papers in current orthopædic literature.

The basement of the building houses a well-equipped laboratory, in which all routine investigations are made and researches are carried out. There are ample facilities for chemical, histological, bacteriological, and experimental work, at the present moment one of the assistants is engaged upon an investigation of the macroscopical and microscopical changes that take place in transplanted fascia lata and the joints themselves after the performance of arthroplasty in dogs.

The gymnasia (*Fig 100*) are three in number, there is an ordinary massage and exercise-room, and there are also two instrument-halls, one filled with Zander appliances and the other with Schultess instruments. Questioned as to his views concerning the efficiency of these merely mechanical methods of exercising, Professor Putti replied that whilst he thought them inferior to the remedial exercises that could be given by a good gymnast, they were at any rate useful in a place where large numbers of patients had to be treated and the staff was limited in number. For example, on the afternoon of our visit 120 patients were expected, whilst during the War there were at one time as many as 800 under treatment.

The museum contains a number of preparations of the ordinary kind and in addition, a large collection of plaster casts and small-scale models, specially made for teaching purposes. The casts illustrate every kind of deformity, before and after treatment, amputation stumps, and especially stumps that have been subjected to Professor Putti's operation of cinematization. There is a large exhibit, also, of the artificial limbs that have been devised for use with the cineplastic and other amputations. The models for the most part illustrate conservative methods of fracture-treatment, and amongst the most interesting are the models of Codivilla's original appliances for the treatment of fracture of the femur by direct traction upon the bone. It is claimed by the Bologna school that Codivilla (who was the second director of the institute) was the first man to invent and apply this method.

Professor Putti (*Fig 101*) is the third Director, he has held the office for about ten years, and served for about fourteen years under his predecessor, Codivilla. He is a whole-time paid officer, and is not allowed to operate or to treat patients outside the Institute, though he may hold consultations outside and may of course, have private patients admitted to the institute under his care. He has seven assistant medical officers, the majority of whom are engaged upon some sort of orthopædic research in addition to the routine duties that they perform. The senior assistants perform a certain number of the operations, and, in the case of paying patients, receive a proportion of their contributions for every operation that they perform. They also act as anaesthetists. All plasters, moreover, are applied by the assistants and they carry on practically the whole of the work in the out-patient department. Professor Putti, it will be realized, is a very busy man, and a man of many parts, he finds time, however, to make himself conversant with the details of the work that is going on in every department and in every department one can see the impress of his enthusiasm, his vigour, and his progressive, orderly mind. Senior surgeon, administrator, editor, consultant, author, university professor, and head of one of the largest orthopædic workshops in the world, Professor Putti nevertheless finds time to make friends with practically

every patient in his hospital and to carry out himself the greater number of the operations necessary, and in walking round his hospital with him, it was a pleasure to see the respect and goodwill with which he was greeted by all the patients and their friends

In connection with the Institute there is, as we have just remarked, a very large workshop, where over 100 men and women are engaged upon the manufacture of artificial limbs orthopædic appliances of every kind, and even surgical instruments. The patients pay just enough for their appliances to make the workshops self-supporting, without any profit being made. The majority of the artificial limbs required by the Government for army pensioners are made here, there are a certain number of limbs of standard type, and others, of special design, have been devised for individual cases of amputation. At this factory also, are produced all the instruments that are used in operation at the Institute including not only simple tools such as scalpels



FIG. 101.—Professor Putti in the wards

and forceps but also elaborate mechanisms such as motor saws and drills, operating tables, and the like

The latest development of the hospital is its country branch, a large building has been acquired in the Dolomite Alps for the treatment of surgical tuberculosis and other conditions by altitude and heliotherapy. This building is now in process of adaptation to its new purpose, and will be ready, it is hoped, by August when 100 patients will be drafted thither from the parent hospital. Motor ambulances will be used, and also special railway ambulance carriages, there being a railhead situated quite close to the new hospital.

Professor Putti is directing his mind more particularly at the present time to the problems of arthroplasty, an operation of which he already has considerable experience. He has performed over 130 arthroplasties and considers that the knee and the elbow are the two most favourable sites for the operation, with the hip as a good third. Cineplastic amputations he rarely performs nowadays, under peace conditions and we did not have

an opportunity of seeing this operation carried out, though we saw a patient undergoing re-education with a temporary limb after having had the operation done

We were fortunate in being able to see an arthroplasty of the knee performed, and to study the results of the operation in several patients. The theatre in which the professor works (*Fig 102*) does not differ in any important detail from any other, it is a large and well-equipped place, all lined with white marble and furnished with many tiers of seats for onlookers and ample top-lighting. The flasks of sterile saline solution are kept at body-heat by means of electric hot-plates. Rubber gloves are used of course, and over these the surgeon and his immediate assistants wear cotton ones, these are changed in the course of an operation as soon as they become soiled, and are frequently moistened with alcohol. Ether is used entirely for anaesthesia and an admirable feature is the recording, throughout the whole operation, of the



FIG 102—In the operating theatre

brachial blood-pressure, an ordinary sphygmomanometer is used coupled to a Tycos gauge but this is of a large size having a six-inch dial, and is mounted on a tall brass rod, well above the anaesthetist's table, where all can see it readily. It is thus possible to know at any moment precisely how the patient is standing the operation and the effects of various manoeuvres can be watched, and technique improved accordingly. The pressures recorded are charted, together with notes of the stages of the operation with which they correspond, the duration of the anaesthesia and the total amount of ether used. In a typical arthroplasty of the knee (the first case recorded below) the pressure varied from 100 to 96 mm of mercury during all the first part of the operation, fell to 80 mm during the chiselling and rasping of the bones, rose to 98 mm again as soon this was completed and remained at 98–100 mm right up to the conclusion of the operation. The duration of the anaesthesia was one hour, and during this time 320 c.c. of ether were used, given by the open drop method.

The chief assistant at operations is the theatre sister, a very able and highly-trained nurse, who knows every stage of every operation, and has everything required in absolute readiness, the surgeon puts out his hand and let us say, a suture of the right-sized catgut threaded in just the right-sized needle, is at once handed to him. Each assistant and nurse appears to have his own specific duties allotted to him and there is very little talking in the course of an operation.

OPERATIONS AND CASES

Case 1—Operation Ankylosis of the knee

A married woman, age 34, had bony ankylosis of the knee, probably the result of an old gonorrhœal arthritis. A tourniquet was applied and a curved incision, convex upwards, was made above the knee, prolonged upwards by a straight median incision. Flaps of skin and superficial fascia were turned back. Linear incisions slightly diverging below were then made on either side of the patella and the quadriceps muscle, right down to the femur, the tissue between the two cuts was divided parallel with the femur, the superficial portion, attached to the patella, being turned down, and the deeper part turned up. These flaps were wrapped in about twenty thicknesses of gauze which was kept moist by being squirted from time to time with saline solution from a large ear syringe.

The joint capsule was divided freely in front of the joint and on both sides, right back to the ligament of Winslow—the latter, however, was left intact, so that, as all subsequent manipulations were carried out inside the joint cavity, there was never any anxiety as to the safety of the main vessels and nerves. Care was taken, however, though the capsule was very freely incised, not to shield it in any way, so that it might heal well afterwards, and the Professor remarked that he never had any fear in any arthroplasty as to the stability of a joint afterwards, but only as to its range of movement.

The crucial ligaments and as much as possible of the soft parts remaining between the femur and the head of the tibia were next cut away. The ankylosis was then divided with special gouges which were made with cranked handles and a blade that was curved so as to accommodate itself in both dimensions to that of the femoral condyles. The knee was gradually flexed more and more as the division of the bony ankylosis proceeded, the back of the joint being supported on an ingenious little metal crutch attached to the table and raised up by a screw as was required. This padded metal crutch, shaped like an inverted L, we saw utilized also in other operations, in the same manner as a Lorenz wedge, and it was much neater and more convenient than the sandbag that is commonly used to hold a knee in the flexed position when operating. The interior of the joint was now completely cleared, and all remnants of soft coverings and articular cartilage were removed. The surfaces were finally smoothed with rasps and files, and shaped as nearly as possible like normal condyles.

The head of the tibia was now similarly treated, special care being taken to preserve a good high ridge, running antero-posteriorly, between the two tuberosities. The hollows on either side of it for the femoral condyles were made, if anything, rather deeper than normal. By the time that both bones were fully shaped, there was a space of about one-third of an inch between them.

A long straight external incision was next made on the outer aspect of the thigh, and a flap of deep fascia was dissected up and entirely detached. This flap was transferred to the knee and fitted perfectly, without any trimming, it was placed with its superficial aspect towards the interior of the new joint cavity, and covered the whole of the condylar surface of the femur and the head of the tibia. It was pressed well to the back, so that its reflexion lay in contact with the posterior ligament of the joint, and was then secured in place by a number of single suture points of fine catgut, attaching it to the capsular ligament of the joint.

The under surface of the patella was then denuded of cartilage, filed, and covered with a flap of soft parts reflected from the tongue of tissue originally left attached to it. Two slits, sagittally placed were then made in the fascial graft, one over the tibial spine, and the other opposite to it, over the corresponding intercondylar notch of the femur. This was for the purpose of allowing connective tissue to form between the two bones at this point, and the surgeon stated that he knew for a fact that it did so form in two cases in which he had had cause to re-open a joint on which he had operated, he had actually seen the dense white fibrous tissue which united the bones though not crucial, these fibres nevertheless formed efficient interosseous ligaments.

The quadriceps muscle was now resutured with lock-stitches of catgut, and the skin with interrupted salmon-gut sutures. Dressings were applied, the tourniquet was removed, and the limb placed on a plaster back-splint, flexed to 30° , which had been previously prepared. As soon as the patient was put back to bed, a heavy weight-extension was applied, the knee being kept flexed to the same extent as before.

Case 2 —Arthroplasty of knee $4\frac{1}{2}$ years previously

The patient had undergone the operation of arthroplasty of the knee $4\frac{1}{2}$ years previously for ankylosis following a gunshot wound of the joint. He was a captain of infantry, about 30 years of age. As he walked to and fro, it was almost impossible to detect which was the injured leg, he was able to stand quite steadily on the operated leg, and said that he could walk for 'many kilometres'. He is still in the army. His range of movement is 180° to 80° . There is slight grating in the joint, but no pathological mobility, fluid is absent. There is still considerable wasting of the quadriceps (over 1 in.) and the Professor remarked that seldom, if ever, was the full bulk of this muscle restored.

Case 3 —Arthroplasty of knee $2\frac{1}{2}$ years previously

A man, age 27, had undergone arthroplasty of the knee $2\frac{1}{2}$ years previously for a severe post-typhoid ankylosis. There had been originally a severe *B. typhosus* pyæmia, and not only had the knee-joint actually suppurated, but there had been osteomyelitis in the femur as well, and a number of peripheral abscesses. The femoral condyles had undergone a certain amount of destruction, and in this case the result was not so favourable as in the first, there was some lateral play, and knock-knee, which the patient thought was tending to increase.

The Professor frankly admitted that the result in Case 3 was not nearly as good as in Case 2, though pointing out that conditions here were comparatively unfavourable. He explained that he classified his results as 'good', 'fair', or 'bad', according as they had movement from 180° to 90° , from 90° to 15° or less than this, and claimed that up to the present he had produced 54 per cent of 'good' results in the case of arthroplasty of the knee.

The joints of both these patients yielded, on palpation a coarse grating identical with that which one experiences on examining a typical osteo-arthritic knee. Fluid, and thickening of the soft parts suggestive of fringes, were totally absent, however. The radiograms showed as the Professor pointed out changes that were extremely like those of osteo-arthritis: some condensation of the articular surfaces where pressure was sustained and proliferation at the free margins, in one case actual osteophytes were present one of which seemed to be loose, and on two occasions we were told it had been necessary to re-open the joints to remove osteophytic loose bodies. It was pointed out that some of the plaques of bone seen near the free margins of the femur and tibia were not really free as they appeared to be but were situated in the attachments of the capsule to the bones, Professor Putti drew an

analogy with the traumatic ossifications that are sometimes seen in the bony insertions of muscles, which, as he said, are not true periosteal ossifications (for true periosteum is not present where muscle tendons are inserted), but fibro-osseous ossifications

Case 3 illustrated a further point of practical importance, namely, the great value of retaining a good median ridge on the tibia, and good concavo-convex modelling of the articular surfaces. Where these are secured all tendency to lateral luxation of the tibia is absent whereas if they are absent some such play may be present. No difficulty has ever been experienced through defective re-formation of the articular capsule and ligaments, they always form perfectly. As a matter of fact however the capsule is only very slightly damaged in the operation as described above, it is only cleanly divided in the horizontal plane, and re-unites easily.

Case 4 —Arthroplasty of the knee 10 years previously

A man, age 40, had had arthroplasty of the knee performed ten years previously for ankylosis following pyo-arthritis secondary to osteomyelitis of the femur which had perforated into the joint. In spite of the severity of the initial infection, a very good functional result had followed upon the operation. He walked without a limp, and he told us that he could cycle thirty-five miles and back every week, to fetch his week's pay. After the War, he served for two years in the army in a trench filling party. At the present time he was engaged as a farm labourer. His knee was chronically swollen, and his quadriceps somewhat wasted, some grating was present, moreover, on movement of the joint. But abnormal mobility was completely absent, and the joint moved freely within the range 180° to 90° .

Case 5 —Operation Congenital talipes equinovarus

This was a relapsed case of ordinary congenital talipes equinovarus in a girl, age about 11. The foot had been fully reduced and plastered three weeks previously. It was now proposed to transplant the tendon of the tibialis anticus to the outer side of the foot to prevent the relapse of deformity that would otherwise have been inevitable.

The tendon was detached at its insertion, and tied very tightly at its extremity with a ligature of fine wire, the object of this was to prevent its flying out after the subsequent fixation. It was pulled up above the annular ligament, and then passed down to the outer aspect of the foot by means of an ingenious tunnelling instrument. This consisted in a hollow tube of metal, slightly flattened, through which was passed a loop of tough wire, by slipping this loop over the end of the tendon, and then dragging it down tightly against the smooth end of the tube, the tendon was held firmly, and yet left undamaged. A small incision over the fifth metatarsal exposed the bone, as far forward as possible, the periosteum was raised over a small area, and the tendon was then secured to the bone by driving through it a fine screw, $\frac{5}{8}$ in. long, having a small washer underneath it. The limb was then put up in plaster by an assistant in the over corrected position.

The Professor said that he preferred this to any other method of tendon fixation, he always fixed tendons to bone, never to one another.

Case 6 —Operation Talipes following old sciatic paralysis

The tibialis posticus was passed behind the tibia to the outer side, and affixed there with screw and washer, as above. The tendons of the flexor longus digitorum were then tenotomized, the toes well manipulated, and the limb plastered.

Case 7 —Operation Double congenital dislocation of the hips in a girl, age 10

There had been no previous treatment. The radiogram showed a well-formed acetabulum and neck of femur, but a head that was lying very considerably above

the proper place. The child, deeply anæsthetized with ether, was placed on a high block of the form shown in *Fig 103*, the hip resting over the excavation, and Professor Putti proceeded to manipulate it into place, stretching the resisting muscles, but neither hacking nor dividing them. In carrying out this manipulation, he rested his hand upon the child's knee, and his chin upon his hand, explaining that he found it easier in this way to estimate just how much force he might safely employ. He emphasized the importance of fairly rapid reduction, dwelling upon the profound shock that was caused by protracted wrenching. In this particular case the manipulations did not occupy more than three minutes, and the spread-eagle plaster was rapidly applied by an expert assistant, nevertheless, when we saw the child next day, she was still showing evidence of fairly severe shock, though she recovered completely within the following twenty-four hours.



FIG 103

Other cases of general interest, which we saw in the wards were one of tuberculosis of the lumbar articular processes in a young man, several cases of congenital dislocation of the hip in various stages of conservative treatment, a very early case of coxa plana, and three examples, from three separate families, of hæmophilic knee, which had formed the subject on the previous day of the Professor's clinical lecture to the undergraduates.

In the laboratory, one of the assistants was kind enough to demonstrate to us the knee-joint of a dog on which he had performed arthroplasty a month previously. The transplant of deep fascia was firmly adherent everywhere to the underlying bone, its surface was slightly roughened, like a piece of 'matt' surface drawing-paper, but was not villous, nor actually ulcerated. We saw also, some microscopical sections of this transplant—the original structure of the fascia was very little altered, but in some of the interfibrillary spaces, just deep to the articular surface there was a well-marked leucocytic infiltration. We were told that in two cases of arthroplasty of the knee in which it had been necessary to re-open the joint the transplant presented a very similar appearance to that which we saw in this experimental preparation. The operation of arthroplasty has been performed upon a series of dogs, and it is proposed to make a complete study of the gross and microscopical changes that take place at various dates after the performance of the operation.

FEMORAL HERNIA, AND THE SACCULAR THEORY

By R HAMILTON RUSSELL, M.F.BOURNL., AUSTRALIA

THE operation for femoral hernia should be a very simple procedure. I wish to deprecate most earnestly what would seem to be a growing tendency to operate for femoral hernia from above Poupart's ligament, I am convinced that this is taking a great hazard, without any compensating advantage whatever. Accidents will most assuredly happen, accidents involving the femoral vein and others involving the bladder, moreover it is, I believe, most important to avoid interference with the fascial structures surrounding the upper opening of the crural canal. Anything we do there will inevitably

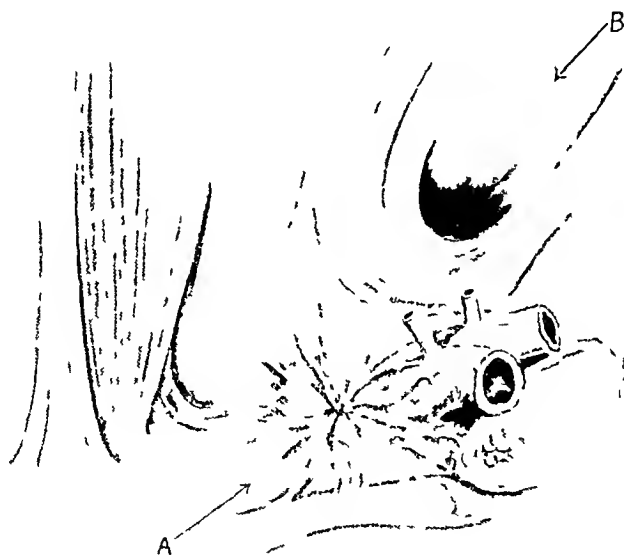


FIG. 104.—Internal view after closure of femoral sac by torsion.
A Femoral sac closed B Inguinal canal

make the opening larger never smaller, and there is no protecting muscular sphincter like that which guards the inguinal canal.

Femoral hernia occurs as the result of the presence of a congenital sac in the crural canal, it occurs under no other conditions, and it will be cured by the removal—or, a better word still, the *abolition*—of the sac. The sac has only to be abolished without doing any damage to the upper opening of the canal in order to abolish the hernia, but it is quite possible, through a lack of wise circumspection so to enlarge the upper end of the canal through

our manipulations that a fresh hernia might actually descend into it, which, strictly speaking, would merit the name of a traumatic hernia

I venture to urge a trial of the following simple procedure, which I have employed for many years

Operation—The sac having been exposed in Scarpa's triangle in the usual way, is first cleanly defined up to the margin of the saphenous opening. It is now opened and should there be a strip of adherent omentum it must be released and pushed back into the abdomen. Next the sac is seized with a pressure forceps and firmly torsioned, the twisting will complete the separation of the sac from the margin of the saphenous opening so that the twist will extend up the canal and close the mouth of the sac at the femoral ring. The twisted sac may now be crushed and ligated with catgut at a convenient spot but no determined attempt should be made to pull the sac down as far as it will come nor should the aim of the operator be directed necessarily to reaching the uppermost limit of the sac, his object will be to apply the ligature a little lower down, for the mouth of the sac is not to be closed by the ligature but by the twist. So much of the sac as is redundant is then cut away, but the remainder of the twisted sac is pushed up the canal pretty firmly and left there, aiming to substitute a convexity for a depression at the site of the crural ring (*Fig 104*). The operation is completed by closing the saphenous opening with one or two catgut stitches, and finally applying a firm compressive dressing. I myself always use over all a rubber bandage (Martin's bandage) very gently applied (barely on the stretch)

Theoretical Considerations—The theory provides for —

1 Closure of the mouth of the sac at the femoral ring with the minimum of interference with the fascial structures there

2 Complete abolition of the sac

3 *Safety*, The greatest danger to be apprehended in operating for femoral hernia has been shown by experience to be injury to the bladder. This accident has happened many times, and sometimes surgeons have been courageous and public-spirited enough to record such misadventures. It appears to me that the plan of torsioning the sac should render any such accident to the bladder practically impossible seeing that by no means could any portion of the bladder enter the twist or escape notice.

The Practical Application of Surgical Principles in Oblique Inguinal and Femoral Hernia contrasted—This little study will be found both curious and instructive. The two herniæ have in common the fact that they are both dependent upon the presence of a congenital sac in the inguinal and femoral canals respectively, but they are singularly divergent in almost every other feature. The inguinal sac is, from its mouth downwards, in close relation with the vas deferens and vessels of the cord, so that in order to detach these structures it must be handled with the greatest freedom. It must be pulled forcibly out from under cover of the abdominal muscles while the detaching finger separates the cord structures deeply into the pelvis. The sac is firmly torsioned, crushed, and ligatured *at its upper extremity*. The fascia transversalis receives scant consideration and protection from recurrence is provided by the musculature.

Now contrast the indications for dealing with the femoral sac. There are no cord structures and there is no musculature. The fascial upper boundaries of the crural canal must be held sacred, there must therefore be no forcible pulling down of the sac or they will be stretched and damaged. Hence the sac cannot be ligatured at its neck like the inguinal sac, the mouth of the femoral sac is closed by torsion from below and then the twisted sac is pushed into the canal, and kept there by any simple device the surgeon may choose, I myself prefer gentle elastic pressure outside the dressing.

HISTORICAL NOTE ON FEMORAL HERNIA AND THE SACCULAR THEORY

It will be noted that in the foregoing article I have taken for granted the dependence of femoral hernia upon a preformed congenital sac. There ought I submit with all deference to have been no need for this note. I have been, however, amazed to find on consulting some of the most recent text-books that the fact of the congenital origin of femoral hernia still seems to be shadowed by uncertainty and doubt in the mind of some authors.

That this is due to the opposition directed against the saccular theory of hernia by so eminent an authority as Sir Arthur Keith I have no manner of doubt, and it would be unreasonable to suppose that an opinion so weighty should be without substantial influence upon the views of anatomists and surgeons. But there is another side to the question. There are some facts of anatomy, and even of embryology, that come more readily into the visual field of the surgeon than into that of the anatomist and the embryologist. It was Sir Berkeley Moynihan who gave us our first lesson in this line of thought some years ago, with his brilliant little essay on *The Pathology of the Living*.

In the matter under discussion the following are historical facts, but I particularly wish to emphasize that I have no thought of animadverting upon our anatomical brethren.

1 For centuries anatomists had the field of femoral hernia to themselves—a field that was not contested by the operating surgeon who only operated for the relief of strangulation, and never for femoral hernia *per se* and anatomists completely failed to recognize that the sac was a congenital structure and the essential cause of hernia.

2 Towards the end of the last century surgeons first began to operate for the cure of femoral hernia, and within a decade or two the fact that the sac was a congenital structure was noted and demonstrated by myself, an operating surgeon and communicated to the Australasian Medical Congress of 1902.¹

3 An incidental remark made in that communication to the effect that hernial sacs would be found in the sites of hernia if a sufficient number of bodies were examined, arrested the attention of R. W. Murray. He took me at my word, examined 100 bodies, found the sacs as predicted in surprising numbers, and thenceforward became a powerful and convinced champion of the view that the cause of all the ordinary spontaneous varieties of hernia is a congenital sac at the site of the hernia.⁴

4 During the years immediately following thanks to the interest displayed by Professor (now Sir Harry) Allen and Professor Berry—his successor

in the Chan of Anatomy at the Melbourne University—in addition to femoral sacs, obturator sacs were discovered on several occasions in the dissecting room. In this way there was also discovered a curious little direct inguinal sac that may be found with moderate frequency coming through the conjoint tendon. It was previously quite well known that a direct hernia would sometimes come through the conjoint tendon, but it was not known that the cause of its doing so was the presence of a congenital sac in that situation. How it comes there I know not, but it is an anatomical fact, and was described and shown in the Presidential address to the Medical Society of Victoria in 1903.²

5 In 1906 "The Saccular Theory of Hernia" was published in the *Lancet*,³ and was energetically criticized by Sir Arthur Keith. A discussion carried on at 'a distance of weeks' between England and Australia was obviously impossible, and it was agreed to leave the question to the test of time and experience with the words, "The saccular theory will fail or prevail as it is false or true."

6 A somewhat long jump from 1906 to 1923. During these years I believe I may safely say that the saccular theory 'prevailed' and became firmly established among surgeons and surgical writers, but I felt less confident as to the views held by teachers of anatomy. All the greater therefore is the significance I attach to an article in the *Journal of Anatomy* for January, 1923, where there appears the report of an investigation into the subject of femoral hernia by J. Allison Panton.⁵ Dr. Panton undertook this inquiry with the object of testing the truth of the prevalent theory as to the reason for the greater frequency of femoral hernia in the female. After a laborious study, carried out with an industry and patience beyond all praise, he amassed a volume of evidence bearing on the accepted theory, but he also did something more, and better. It is a little difficult to make out how much or how little he had the saccular theory in mind at the beginning, but it is evident that he was amazed at the end of his work to find that he had clearly demonstrated the congenital origin of the femoral sac.

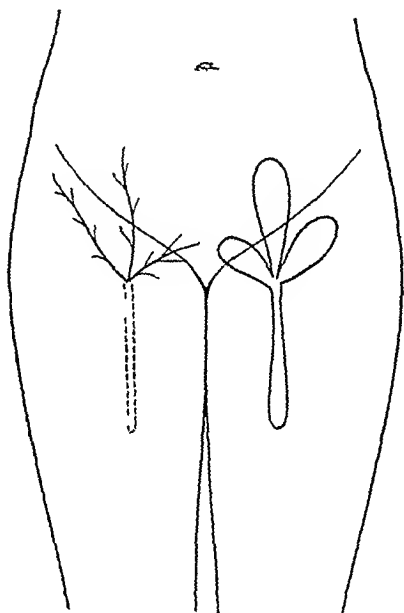


FIG 105.—Right side, branches of common femoral artery. Left positions assumed by femoral sacs.

I have no desire to prolong this article by attempting to record the evidence already advanced in proof of the congenital origin of the femoral sac, but I should like in conclusion to re-state one matter of surpassing interest which is concerned with the course taken by a femoral hernia of any size after its emergence from the saphenous opening. No explanation worthy of the term had ever, prior to 1902, been advanced by any surgeon or

anatomist as to the reason why a femoral hernia should usually turn upwards over Poupart's ligament, but should sometimes pass in the opposite direction down the thigh sometimes outwards toward the iliac spine and sometimes inwards toward the pubes. It is disappointing to read in a modern text-book the explanation that "the hernia follows the path of least resistance", or words to that effect. How can there be four different "paths of least resistance"? The explanation becomes at once simple and obvious as soon as we recognize that the sac is a congenital structure. The accompanying diagram (*Fig 105*) has already been used by me on two occasions.^{2 3} It shows on one side the branches of the common femoral artery, and on the other the various positions assumed by femoral hernia when large enough, and the size of a femoral hernia is determined by the size of the preformed sac far more rigidly than is the case with inguinal hernia. Now it takes very little thought to determine how the arterial branches depicted have come by their curious retrograde course when once that is understood all difficulties with regard to the behaviour of femoral hernie vanish. A sac contemporaneous with the developing arteries in the embryological limb-bud will be subject to the same developmental evolutions and will be compelled to take up the same positions, so far as one can see, it would appear to be a matter of mere chance into which of the four positions the sac will be drawn. So the 'path of least resistance' may be a perfectly correct expression to use in describing the course of femoral hernia, but solely on one condition, which is that the word 'hernia' shall be taken as meaning the hernial contents only, and shall not include the sac, for the 'path of least resistance' is the interior of the sac.

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MALIGNANT DISEASE OF THE UPPER JAW WITH SPECIAL REFERENCE TO OPERATIVE TECHNIQUE.

BY E. MUSGRAVE WOODMAN, BIRMINGHAM

*(Being the Hunterian Lecture delivered at the Royal College of Surgeons of England
on January 31, 1923)*

IN the year 1671, Richard Wiseman, Sargent Surgeon to King Charles II, describes an operation on the upper jaw in the following words —

“ A man about 28 years of age came out of the country with a cancer on his left cheek stretching itself from the side of his nose close under the lower eyelid to the external canthus, so making a compass downwards. It was broad in its basis, and rose, capped like a sugar loaf. The cancer threatened his eye with inflammation, and he hastened up and importuned me to undertake it. I complied with his desire and four or five days after, having prepared all things ready, the actual cauteries, digestives, desensitives, and bandages, I pulled the tumour towards me with one hand and made my incision close to the eyelid and cut it smooth off. Then viewing our work and observing some relic of cancer remaining above the external canthus, we consumed it by actual cautery and dressed the wound with our digestives, with embrocation, desensitives, and moderate bandages ”

This is the earliest extant account of an operation in the upper jaw which I can trace and in a simple way foreshadows the improved technique as it is known to-day. Undertaken as it was centuries before the introduction of anæsthetics or before the value of antiseptics was conceived, the operation demanded a courage and patience on the part of the sufferer which is amazing.

At a far earlier date, Ambroise Paré gives a comprehensive and accurate account of the clinical appearance of malignant disease in the upper jaw, accompanied by the remark that it must not be touched by the hand because it savours of the nature of a cancer. Percivall Pott displayed a very considerable interest in polypus of the nose, and gives an incisive description of the difference between simple and malignant cases, but directions for operative treatment are conspicuous by their absence. In the works of Hunter and Abernethy I can find no record of work done in this sphere. To Professor Lizzais, of Edinburgh is attributed by Liston the credit of introducing the formal operation of removal of the upper jaw.

Liston himself undertook numerous operations of this description, and the following maxim dominated his work —

“ The more rapidly, consistent with safety, these operations—which under any circumstances are of great severity and attended with much suffering to the patient—be accomplished, the better ”

The late Sir Henry Butlin took a great interest in this difficult field, and did much to increase the success of operative treatment of malignant disease in the jaws. Himself a great operator, his work on the anatomy and surgery of the lymphatic glands of the neck especially in reference to malignant disease, has proved of great value to those who come after him.

The confines of space necessitate a ruthless restriction of the field that can be covered in this paper. Pathology can only be lightly dealt with and the clinical side of the subject can hardly be touched at all on the present occasion.

Classification — I have attempted to classify the

FIG 106 — Section of an endothelioma arising from the ethmoid, showing the rather advanced vacuolation in the cells

malignant neoplasms in the upper jaw according to the site of origin, as follows —

- a* Palate and alveolus
- b* An sinuses
- c* Epipharynx, with invasion of the jaw
- d* Cheek, with invasion of the maxilla

Pathology — In no part of the body are such varied and extensive types of growth to be found, and almost every histological structure enters into their composition. The lower portion of the superior maxilla takes part in the formation of the mouth and consists of dense bone covered by fibrous periosteum and a stratified squamous epithelium. In these tissues sarcomata of all varieties are common and rapidly malignant,



FIG 107 — Typical spheroidal celled carcinoma. Notice the cells arranged in large acini, with a fibrous stroma starting each group

but fairly accessible to treatment. On the other hand, an epithelioma is moderately slow in growth, ulcerates, and spreads quietly until it perforates through the palate or alveolus into the antrum. It may be taken as a general rule that any growth arising around the antrum is drawn as it were to a centre, and sooner or later seeks this inviting space.

Of the many interesting and rare tumours of the teeth and dental papillæ, I can add nothing to the work of Sir Anthony Bowlby, Sir John Bland-Sutton, or Sir Frederick Eve.

The second function of the upper jaw is entirely different, and it has to do with respiration and the



FIG 108.—A columnar celled carcinoma, showing typical branching processes covered with columnar cells. The general appearance almost suggests a bladder growth.



FIG 109.—A squamous celled carcinoma of an unusual type. The section through various portions of the growth showed in one place a very aberrant type of squamous celled carcinoma, in another an ordinary epithelial papilloma, and in yet another a fibromatous condition in which the projection was covered by a single layer of squamous epithelium.

resonance of sound. To fit it for these duties the bones are delicate, vascular, and covered by a ciliated epithelium. The tumours arising in this portion of the maxilla do not often contain bone. Macroscopically they are usually soft, succulent, friable, and vascular, and there is little difference between the morbid appearance of sarcoma and carcinoma. It is very difficult to obtain any reliable figures as to the point of origin of the growth. I believe in the majority of cases the tumour originates in the ethmoid, and only invades the antrum as a line of least resistance.

Consider the anatomy of the ethmoid for a moment. Composed of a mass of small cell-spaces

with septic infection retained in little pools throughout its substance, the conditions are eminently favourable for the development of malignancy. The antrum, on the other hand, is a clean sinus usually full of air and lined with ciliated columnar epithelium, endowed with the property of sweeping away and to a large extent of destroying infection.



E. D. D. Davis states that in no single case out of a series of twenty could it be definitely shown that the disease arose in the mucopariosteum of the antrum. If this proposition is correct the significance is obvious, the ethmoid lies outside the superior maxilla, and mere removal of this bone will not eradicate the growth.

Turning to microscopic anatomy (Figs. 106-110), there is some divergence of views as to the relative frequency of the various types (*see Table I*), and

this is due to the histological difficulties encountered

Table I—TYPES OF GROWTH

NAME	NO. OF CASES	TYPE OF GROWTH	
Mollison	17	Carcinoma	14
		Sarcoma	3
Harmer	23	Carcinoma	18
		Endothelioma	5
Davies	21	Carcinoma	10
		Endothelioma	7
		Sarcoma	4
Woodman	30	Carcinoma	8
		Endothelioma	6
		Epithelioma	8
		Sarcoma	8

Many tumours are atavistic, in others an entirely different appearance is present when sections are taken from separate portions of the same growth.

Complications—True to its instinct a growth when it has reached the limits of the antrum erodes the bony wall where resistance is lowest. It not infrequently extends upwards through the floor of the orbit. A proptosis of the orbit results and is not serious unless accompanied by injection of the vessels and oedema of the conjunctiva, when invasion of the sphenoidal fissure is indicated.

Case 1—M male, age 47. This patient came under my care with a recurrent malignant growth in the right upper jaw. The growth had extended upwards, and could be felt beneath the lower eyelid. It projected from the orifice of the nostril in the form of a bleeding and somewhat fungating mass.

The superior maxilla was removed, including the orbital plate, and the growth did not extend into the pterygomaxillary fossa, but upward into the ethmoid, and backward into the sphenoid and frontal sinus, which contained pus and polypi, and a small bud of growth was just beginning in the lumen of the cavity (Figs 111-112). The operation area was seared with the diathermy button.

On examining the naked-eye specimen the growth was found to have perforated the infra-orbital margin and to project into the cavity. Microscopically it proved to be a malignant endothelioma eroding the bone (Figs 113, 114).



FIG 111—Case 1. X-ray photo, antero-posterior of skull showing a completely dull right antrum, ethmoid frontal sinus and the whole of the side of the nostril in shadow.



FIG 112—Case 1. X-ray of the skull showing the shadow in the frontal sinus and the sphenoid sinus.

Partial or complete blindness may be due to toxic neuritis of the ophthalmic nerve and is not a contra-indication to operation unless accompanied by atrophy. A further point at which the bone of the antrum is thin is situated just below the infra-orbital margin, and here invasion into the soft tissues of the cheek is common. On the other hand, the bony floor of the antrum is dense, and invasion of the palate from above is rare and growth only appears on the alveolar margin through the socket of a tooth.

If we assume that malignant disease usually commences in the ethmoid the invasion of the other

sinuses is readily explained. The sphenoid is closely connected with the posterior ethmoidal cells and is often continuous with them while the direct

leading to the frontal sinus is in direct relation with the anterior portion of the ethmoid. Whether the frontal sinus is often the seat of growth is a matter of dispute, but in some cases it certainly is so and in most the

frontal sinus is the seat of suppuration. The sphenoid is involved in the majority of malignant cases by direct extension.

Involvement of the meninges is a serious and often hopeless complication. When it is remembered that the roof of the ethmoid is formed by the thin plate of bone forming the floor of the anterior cranial fossa, it must be evident that in the complete eradication of disease the crura will be exposed on many occasions and often over a considerable area. Needless to say no operation should be undertaken in the presence of meningeal infection, but it is important to determine whether this infection is due to sepsis or to growth.

Sepsis usually accompanies malignant disease of the jaw, and all the uninvaded sinuses become full of pus



FIG 113—Case 1. Microscopical section of the growth showing the typical vacuolated cells of an endothelioma.

nant disease of the jaw, and all the uninvaded sinuses become full of pus

Case 2—Mrs B, age 50, was sent to me from the country with double ethmoidal polypi. Examination of her nose showed it to be completely full of rather vascular fleshy polypi on both sides and all the sinuses were dull. She complained of headache and general ill health. I operated in the upright position for polypi, and found them very extensive in distribution and highly vascular. On microscopical examination they proved to be myxosarcoma, and the basal portions were filled with numerous sarcomatous cells. They recurred very rapidly, and ten days afterwards I reflected the cheek on both sides and everted all the sinuses, every one of which on both sides of the nose was found to be full of growth. She suffered from a severe attack of meningitis which nearly terminated her life, but she recovered, and has now remained free from growth and is in perfect health. Operation July, 1920.



FIG 114—Case 1. Another portion of the growth, showing erosion of the orbital margin.

Lastly, the accidental wounding of the dura mater of the anterior fossa is not of necessity a dangerous proceeding.

Case 3—A, male, age 37 This patient had an extensive epithelioma of the cheek involving the eyelids and invading the ethmoid and antrum (*Figs 115, 117*). The whole area, including orbit and upper and lower lids, was excised (*Fig 116*). When removing the growth from the dura mater in the region of the cribriform, a $\frac{1}{2}$ -in incision was accidentally made in the dura with scissors, and cerebrospinal



FIG 115—*Case 3* Extensive ulcerated area involving the whole of the right orbit. Note the indurated masses of the growth



FIG 116—*Case 3* The patient after operation, showing the whole area of the orbit excised, and the wound area covered by skin



FIG 117—*Case 3* Colour microphotograph of the growth showing columns of epithelial cells radiating in different directions, with a marked cellular reaction of the invaded tissue

fluid escaped. The edges of the dura were sterilized with iodine and carefully sutured, and the wound was packed with a drainage tube leading down to the dura mater. Uninterrupted recovery followed, without even a rise of temperature or a headache.



FIG. 118 — Case 5. Photograph, full face. Note the broadening of the base of the nose, with the deviation of the axes of the eyes outwards and the pitting of the skin where it was adherent to the growth over the bridge of the nose.

The last and perhaps most difficult extension to deal with is backwards into the pterygoid fossa. Here the dense muscles of mastication are involved and the growth worms itself into the loose vascular and areolar tissue of this region and leads early to deep lymphatic involvement.

Case 4—T, male, age 12. An ulcer was excised from the angle of the cheek on the left side near the upper wisdom tooth. This proved to be epitheliomatous, and a year later he developed pain in the face and a sinus leading from the antium freely discharged pus in the region of the previous operation. An X-ray examination showed the left intrum and ethmoid to be dull. The upper jaw was excised on the left side and the growth was seen to have perforated into, but only partly filled, the antium. It had, however, extended widely backwards into the region of the external pterygoid muscle beneath the maxilla bone and entered the sheath of the temporal muscle. The latter extensions were destroyed by diathermy.

The patient made a good recovery, and is at present free from recurrence.

Radium—The use of radium is of comparatively recent date, and the results are still *sub judice*. Radium attacks the more highly specialized cells less than the primitive ones, a round-celled sarcoma is far more vulnerable than any other type of tumour, and when attacked by a dose of emanation it often melts away like an inflammatory mass.

Case 5—S, male, age 42. This man had a slowly but actively progressing sarcoma growing from the base of the skull, which had eroded the ethmoid on both sides, destroyed the septum, and was pushing out the nose and tilting the orbits outwards so that conjugate vision was impossible (Figs 118, 119). The growth was a giant-celled sarcoma (Fig 120). It has apparently been entirely destroyed by radium, and the nose is contracting slightly. The man is well and in regular work.



FIG. 119 — Case 5. Photograph, side view showing the obliteration of the sulcus at the bridge of the nose.

Case 6—F, age 27. Patient was admitted to hospital with a large swelling on the left side of the palate and over the sphenoidal fossa. This appeared to be a gumma, and resembled a quinsy, but there was no pain. Swelling extended so

rapidly that a tracheotomy was required in the night and a section was taken. This proved to be a small round celled sarcoma growing from the posterior ethmoidal region and blocking the back of the nose. In the next 100 mgrm of radium were buried. The whole tumour was destroyed, the tracheotomy tube removed, and the patient discharged (Fig 121). Three weeks later he came back with an exactly similar condition in the right side of the soft palate. Radium was placed in this swelling and it also disappeared within twenty-four hours. The patient was again discharged and came up a month later with a large fixed mass in the suprathymic fossa. Radium being buried in this, the tumour once more disappeared. The prognosis is bad, it being almost certain that the growth will appear in the mediastinum and probably prove fatal.

Radium has a distinct value in dealing with sarcoma, but in only a few cases will it cure.

The tumour should be exposed and radium buried in the substance while a flat application to give a cross-fire of radiations

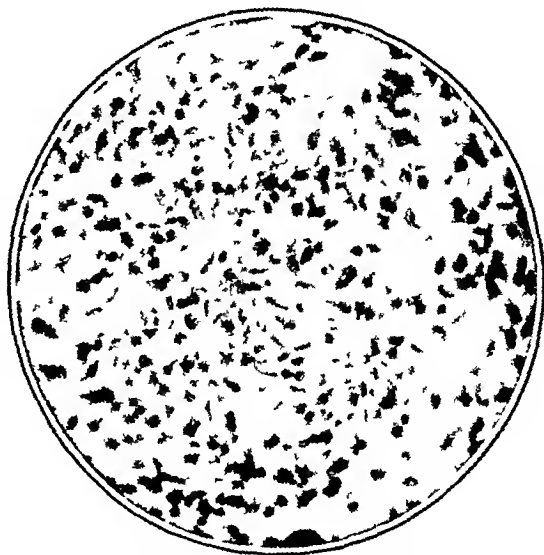


FIG 120—Case 5. Microphotograph of the growth. It is a giant celled sarcoma with a typical multinuclear giant cell in the centre.

properly filtered is placed externally so as to pierce the growth. It is now largely given to small glass tubes of emanation introduced throughout the growth and placed in the form of a barrage around the edge. Radium has little value in dealing with a carcinoma or epithelioma.

The question of possible damage to the eye when radium is placed in the ethmoidal region is a matter of some importance. Fortunately radium has little effect on the highly specialized cells of normal tissue, and damage to the sight is extremely rare.

My experience of the new Erlangen method of X rays has not been so happy as that of radium. Fenzl states that the whole question depends upon giving every cell of the growth a lethal dose, and this dose varies according to the kind of growth. The lethal dose for round-celled sarcoma is less than that for a spindle- or mixed-celled sarcoma. The question of sepsis complicates



FIG 121—Case 6. The patient after treatment, showing the healed tracheotomy scar.

the situation and most growths are septic. It does no harm to give an aseptic growth considerably more than the lethal dose, but there is considerable harm in giving more than a lethal dose to a septic growth, and failure

results. When the growth is infected it should be sterilized with ionization, and treated on the following day by intensive X rays.

Diathermy—The use of diathermy marks a real surgical advance in the treatment of malignant disease in certain regions. The aim is to sterilize the whole growth by a process of coagulation necrosis.

In a cancer of the breast or bowel it is possible to excise the disease completely by passing through healthy tissue—and here diathermy has no field. On the other hand, in disease of the mouth or throat it is often impossible to avoid contamination of the wound by cancer cells, which are sown on to the raw surface and it is to the effusion of infected blood and lymph that this is largely due. The advantages attending the use of diathermy are many. There is an absence of implantation of malignant cells. The cut surfaces of the blood and lymph vessels are sealed. There is no loss of blood, and shock is very slight.

The proceeding is simple. The growth is transfixed with a pronged electrode, and the current turned on up to 1½ amperes. The tissue becomes white, blanched and dry. The current is then switched off before sparking commences, and a further area is attacked, and the coagulated tissue is broken away with forceps. Finally the whole surface of the excavated area is sterilized with the button electrode.

There are certain disadvantages which must be considered —

1. Owing to coagulation proceeding beyond the area of the electrode vessels and nerves cannot be seen.

2. During the application of the current ether must not be used as the anæsthetic.

3. Although at the end of operation the affected area is sterile it does not remain so, and there is a period of sloughing which in the case of tendon tissue or of bone takes a long time and is often very offensive during the process of separation.

4. Secondary hæmorrhage may occur. The rule should always be to ligature the vessel when diathermy is used in the neighbourhood of a large artery.

In order to overcome these disadvantages the best results can be obtained in the upper jaw by a combination of diathermy with surgery. The growth should be fully exposed, destroyed by diathermy, and then removed and the raw surfaces of bone and soft tissue sterilized by the electric current.

OPERATIVE TECHNIQUE

In dealing with the operative technique I desire at the outset to call attention to the necessity of modifying the operation according to the site and extent of the growth. In an epithelioma of the palate it is sufficient to remove the half of the palate and alveolus involved, unless the antrum has been perforated and invaded by growth. In an alveolar sarcoma a similar conservative operation will be sufficient, and no advantage whatever would accrue from removal of the infra-orbital plate. On the other hand a growth in the antrum probably arises from the ethmoid and the operation of removal of the superior maxilla is totally inadequate.

The an-cells form one indivisible unit from the bottom of the antrum to the root of the frontal sinus, and from the pterygomaxillary fossa to the posterior wall of the sphenoidal sinus there is a continuous chain of epithelial cells. Thus the ramifications of this system extend far beyond the confines of the superior maxilla and sufficient elasticity must be given to the operation to allow for alteration in design to meet each individual case.

The difficulty of successfully removing a growth in the upper jaw lies in the fact that two of the three cardinal principles of removal of malignant disease are usually impossible to carry out. It is generally impracticable to remove the growth through healthy tissue and secondly it is not possible entirely to prevent dissemination of diseased blood over the wound area, but it is just here that the assistance of diathermy is most valuable.

There are certain classes of cases which are generally inoperable (see Fig 122) —

1. Sarcoma arising from the base of the skull and secondarily involving the maxilla.
2. Extensive involvement of the pterygomaxillary fossa.
3. Cases showing persistent meningeal infection.
4. Extensive invasion of the back of the eye suggesting involvement of the cavernous sinus—in which case the removal of the eye will not cure the disease.

On the other hand involvement of the skin of the face or of the eye itself is not necessarily a contra-indication.

Position—There are two matters at this point which deserve some attention. In the first place the posture of the patient during operation is important. The upright position has a great deal to recommend it. First of all, the blood-pressure to the head is considerably reduced, and there is an absence of nasal congestion. Secondly, the visibility is greatly improved, and not only can the operator see exactly what he is doing, but the steps

of the operation can be clearly seen by those around. In the third place, there is a remarkable absence of shock, the patient often leaving the table



FIG. 122 — Case 7. G. age 35. A very extensive endoductoma of the right superior maxilla which had ulcerated through into the mouth and upwards into the cheek over the maxilla. The growth was traversed with numerous fistulous tracts and impregnated with pus. Operation was impossible and radium refused.

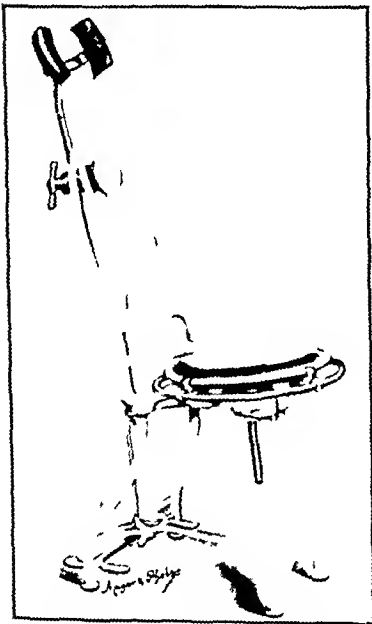


FIG. 123 — Chair used in upright position which can be instantly lowered at will by the pressure of a foot pedal.

The usual practice is to put the patient when anesthetized on the chair in the horizontal position and carefully raise it to the vertical by drawing forward the back of the chair.

with a good pulse. And lastly, the amount of anæsthetic required to keep the patient at a sufficient depth is very much less than in the recumbent position. With a properly equipped chair (*Fig 123*) the position presents no difficulties.

Anæsthetic—The anæsthetic used is a matter of very material importance to the operator and the latest advances in the use of intratracheal ether (*Figs 124-126*) have, in my opinion, reduced the mortality to as low as almost any operation in surgery.

The technique now made use of is shortly as follows. Induction takes place by ethyl chloride and ether, and when the patient is fully anæsthetized



FIG 124—*Case 8*. W., age 15. Patient in vertical position under anæsthetic. Note the intratracheal tube coming in from the left side and the airway.

This patient was sent up with a repeated and severe epistaxis. On examination he was found to have an extensive sarcoma growing from the sphenoid involving the right ethmoid and extending into the antrum on the corresponding side.

blood a minimum quantity of ether is used and an even depth of anæsthetic is maintained. During the last ten minutes oxygen is blown in, and at the completion of the operation the swallowing reflex should always be present.

Chloroform is never given unless the use of diathermy necessitates its employment.

Operation—The incision commences above in the centre of the eyebrow, and it is carried downwards midway between the bridge of the nose and the inner canthus of the eye, and thence follows the line of Ferguson's incision down the groove at the side of the nose and round the external nares to reach the philtrum, and thence divides the lip. On the buccal surface of the cheek the greatest care should be taken to divide the mucosa low down immediately above the neck of the teeth and to elevate it throughout the

the mouth is opened and the post-nasal plugs are carefully packed into the back of the nares and a large intratracheal catheter is passed through the larynx under vision. An anæsthetic airway the proper length and curve is then inserted at the back of the pharynx and the mouth packed with gauze. Lastly a sterile towel is passed across the mouth and tacked over the airway and passed round the back of the head. Ether vapour is then pumped in from the tube in the mouth directly to the lungs under a pressure of 20 mm. of mercury by an electric motor, and the anæsthetic is maintained indefinitely by positive pressure. There are two distinct advantages for this class of operation in the use of intratracheal ether. There is no danger whatever of the inspiration of

MALIGNANT DISEASE OF UPPER JAW 165

whole length of the incision. Thereby a considerable portion of harmless mucous membrane is saved, and can be sutured in position to the raw area on

Fig. 125—Case 9. B. male age 46. An extensive endothelioma had arisen from the ethmoid. The growth had perforated through the superior maxilla and appeared under the skin which it had infiltrated to the outer side of the eye and the sight was lost on this side. In this case the upper lip was saved and detached from the cheek, the skin being united to the mucous membrane throughout the primary incision. The growth was then isolated above from the forehead, round the malar bone, and the whole superior maxilla together with the orbit, the ethmoid and the nasal bones removed en masse. Extensions were then seen to have taken place in the frontal sinus and in the sphenoid. These were removed and the wound was closed over as far as possible. A period of time must elapse before any further operative treatment can take place. I then propose to close the wound in the face by plastic flaps to reconstitute the orbit.

In this figure is seen the patient before operation. Note the nodules of the growth beginning below the outer canthus of the eye, at the side of the nose on the upper eyelid, and at the inner end of the eyebrow. The steps of the operation are shown in Figs. 126-130.

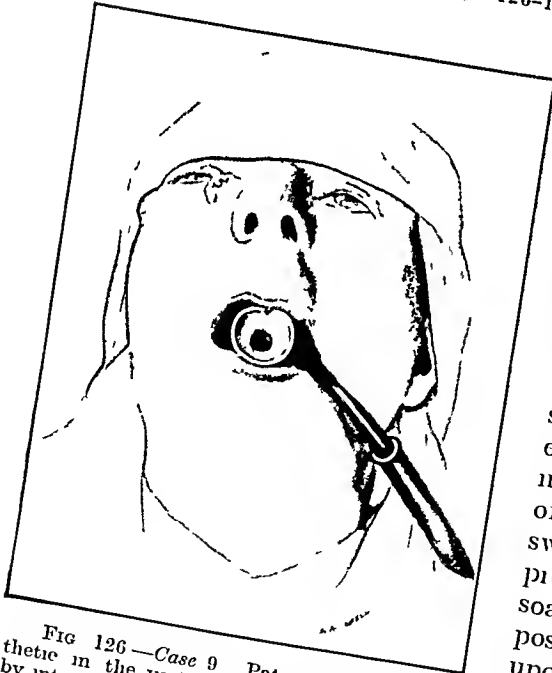


Fig. 126—Case 9. Patient under anesthetic in the vertical position, anesthetized by intratracheal ether.

the inner side of the reflected cheek. The cheek flap is then drawn aside, and care is taken to carry the knife down through the periosteum to the bone, particularly on the inner side of the nose. If the growth has extended backwards, and especially if its base is in the pterygoid muscles, it is necessary to make use of the horizontal incision beneath the orbit, but this should be avoided where possible. The cheek flap should be protected from infection during the process of removal of the growth, and the raw surface is swabbed with tincture of benzoin and protected with a small gauze pad soaked in the solution and sewn into position. The subsequent steps depend upon the nature, origin, and extent of the growth. The operation must be carefully planned in its exact details before the patient comes to the theatre, and there should be no delay

or hesitation in the technical details at this stage.

If the growth is confined to the lower half of the superior maxilla and does not involve the upper an sinuses, the lower part of the upper jaw is

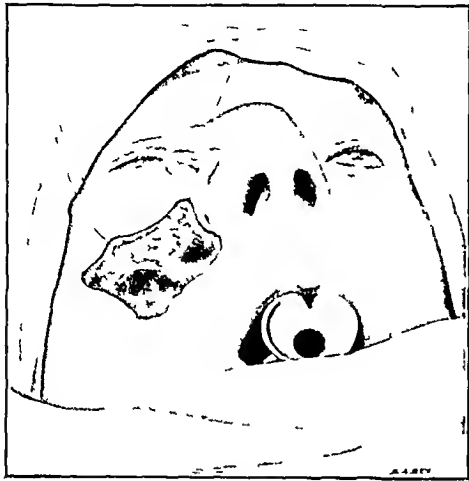


FIG 127—Case 9 Incision of the soft parts below the growth and suture of the skin below the mucous membrane of the mouth, so as to preserve the upper lip

removed leaving the infra-orbital plate intact To do this a fine chisel is taken and a horizontal incision is made following and parallel to the lower margin of the orbit at about the level of the infra-orbital foramen This is carried through the ascending nasal process of the superior maxilla to enter the nose and through the body of the malar bone to the pterygo maxillary fossa The line of attachment of the cartilages of the nose to the bone is then divided and if the nose itself is not involved the mucoperiosteum can easily be elevated and the whole of the soft parts of the nose turned inwards without opening the cavity The hard palate is then divided sagittally from the alveolar process backwards The separation is completed by detaching the soft palate by a horizontal incision, and lastly separating the back of the maxilla from the pterygoid process by driving a strong osteotome in between these bones This partial incision, when it is adequate, gives very satisfactory anatomical results, the orbital cavity is not opened, and there is no dropping of the eye with consequent failure of alignment Further the nasal cavity is also unopened and its important functions remain intact This proceeding is suitable for most growths arising from the palate and alveolus, even when they have perforated the antium, provided the limitations of the growth can be accurately seen and delineated

Very different is the proceeding which must be adopted when the malignant changes have involved the upper an sinuses or the orbit, in which case a most extensive exposure is required to eliminate the disease The complete upper jaw must be removed in the first place, and the whole of the side wall of the nose Only too often this proceeding is considered sufficient for removal of the growth,

removed leaving the infra-orbital plate intact To do this a fine chisel is taken and a horizontal incision is made following and parallel to the lower margin of the orbit at about the level of the infra-orbital foramen This is carried through the ascending nasal process of the superior maxilla to enter the nose and through the body of the malar bone to the pterygo maxillary fossa The line of attachment of the cartilages of the nose to the bone is then divided and if the nose itself is not involved the mucoperiosteum can easily be elevated and the whole of the soft parts of the nose turned inwards without opening the cavity The hard palate is then divided sagittally from the alveolar process backwards The separation is completed by detaching the soft



FIG 128—Case 9 The incision round the growth extending down the side wall of the nose and above the eyebrow and across the malar bone The soft tissues have been incised down to the bone in all directions

but it cannot be too strongly emphasized that this is a stage in the access to and exposure of the deeper and more delicate parts round the skull base.

By no operation is it possible to remove such a growth in one piece without breaking across various extensions and a very brief consideration of the anatomy would easily convince the surgeon that this is so. The whole of the ethmoid up to the cribriform plate should be systematically removed. Then the sphenoid should be opened, the anterior and inferior walls of the sinus cleared away and the contents everted. In a similar manner the frontal sinus must be dealt with. The duct is traced upwards and all the fronto-ethmoidal cells and the whole of the floor of the frontal sinus are removed. It is never advisable or necessary to remove the anterior wall, thus considerable deformity is saved and what is even more important the risk of infecting the diploic veins avoided.



FIG. 129.—Case 9. Superior maxilla excised together with the ethmoid and a little of the orbit. The dura mater of the anterior fossa was exposed and is seen in the upper part of the wound area. The fat of the pterygomaxillary fossa is shown in the lower portion.



FIG. 130.—Case 9. Wound narrowed somewhat by bringing in the flaps after the slough has come away. The large granulating area of the wound is completely covered by a skin graft.

Several cases of osteomyelitis have been recorded as the result of Killian's method of exposure of this sinus. If possible an endeavour should be made to leave the periosteum of the orbital cavity intact, but nothing must be sacrificed to the complete eradication of the growth. Special attention must be paid to the fat and muscles of the pterygomaxillary fossa and to a common extension of the growth backwards through the internal nares to enter the pharynx where it lies free in the cavity. Extension into the pterygoid fossa I regard as being the most difficult to remove and one of the most frequent causes of recurrence. Having perforated the thin posterior wall of the antrum, the growth finds itself in a region highly vascular, and it spreads rapidly between the fasciculi and planes of the pterygoid muscle into a region where access is bad and elimination very difficult. After healing takes place, there

between the fasciculi and planes of the pterygoid muscle into a region where access is bad and elimination very difficult. After healing takes place, there

is often a residual fibrosis in these muscles which leads to considerable difficulty in opening the mouth

At the conclusion of this complete operation the frontal sinus, the sphenoid, and cribriform plate should be freely exposed and form one large cavity leading to the mouth below, limited internally by the septum of the nose and externally by the replaced cheek flap

In the course of the operation little trouble will be experienced from hæmorrhage. The vessels on the cheek flap are easily caught as they are divided. On the removal of the superior maxilla, which should be carefully done between the fingers the internal maxillary artery is brought forward in the loose fat and can often be clamped with curved tonsil forceps before being divided. If divided it can very easily be picked up and ligatured.

If there is contamination of any area in removal of the growth the best course is to run over the whole part with a flat button diathermy electrode.

Lastly, in cases of sarcoma it is always wise to insert radium in the operation area for twenty-four hours after operation.

In suturing, great care must be exercised in the region of the inner canthus of the eye. The periosteum should be picked up and sutured as a separate layer and the skin gradually approximated by a continuous stitch. The dressing which has proved most effective is one of gold leaf. A clean healing wound results, and no other dressing is required after the first twenty-four hours.

METHOD OF DEALING WITH LYMPHATIC GLANDS—It is a matter for discussion whether it is wise or necessary to remove the glands in all cases. It is a fact that in many growths of the superior maxilla no glands are affected—especially is this so of the carcinomata. On the other hand, with a squamous epithelioma of the palate or alveolus the glands should always be completely dissected out following the technique so ably laid down by the late Sir Henry Butlin. It is not possible to be sure which group of glands will be affected, or in fact, on which side of the neck they will appear.

Case 10—S, age 20. Primary endothelioma of the septum. The only gland involved was the superficial parotid on the opposite side of the neck, and the microscopic appearance was that of the primary growth.

The microscopic diagnosis of the tumour will be of some assistance in deciding the point in each individual case, but in the absence of palpable glands the operator will probably prefer—and rightly—to await the signs of glandular infection, though naturally a close watch must be kept over the patient.

LIGATION OF THE EXTERNAL CAROTID ARTERY—Another point of debatable interest is the question of the desirability of ligation of the carotid artery before operation. Sir Henry Butlin found that ligation of the external carotid was of no use alone, and Sir F. Treves holds that preliminary ligation of a large artery is not a necessary or desirable proceeding. In my own case, for the last two years I have not tied the artery.

LARYNGOTOMY—Until quite recent years laryngotomy was an indispensable preliminary to attacking the upper jaw. The airway was then free

and untrammelled by the actions of the surgeon the anæsthetist was out of the way and it enabled the pharynx to be plugged off with sponges so as to preclude the entrance of blood to the air-passages. But is there *no* disadvantage in making a direct opening into the air-tubes? Additional operating time is involved there is a cricothyroid artery which sometimes is troublesome and there is always a remote possibility of blood leaking past the sponges in the throat. It seems certain therefore that in the future we shall make use more freely than ever of intratracheal ether and it is to this anæsthetic and to this alone I attribute the remarkably low mortality of the modern operation.

After-treatment The main principles to be held in view are to obviate deformity and to prevent recurrence. Dealing with the question of deformity first—experience teaches that there are certain situations where trouble may be expected. In the first place at the inner angle of the eye the skin of the side of the nose is thin delicate and easily curls inwards and lies in contact with



FIG 132—Case 12 C, male age 26. This patient had a primary epithelioma of the palate, which had perforated into the antrum and filled this cavity with growth. The upper jaw was removed, together with the palate. The orbital plate was left intact. Note the absence of facial deformity resulting.

the periosteum of the nasal bones and it is only too easy to leave an unsightly hole in this position (Fig 131).

To prevent this the skin incision should be made well on to the side wall of the nose and away from the eye and the greatest care taken in the elevation and retention of the periosteum, which should be subsequently sutured back in a separate layer to the skin.

Œdema of the eyelid is a great and constant bugbear, and is sometimes unavoidable. By omitting the horizontal and infra-orbital portion of Ferguson's incision I hoped to avoid this deformity but without marked success. The determining factor appears to be the orbital plate of the superior maxilla (Fig 132). Where this can be left, œdema of the lid is not permanent but where it has been removed however careful the operator is

not to disturb the ligament of Lockwood or the attachments of the capsule of Tenon, the eye as a whole drops and the under surface acquires fibrous attachments to the tissues forming the posterior wall of the wound area. To obviate this it is recommended that the temporal muscle be split vertically down to and through the coronoid process of the lower jaw, that this musculo-bony tissue be swung across beneath the orbit like a sling, and the



FIG 131—Case 11 W, male age 26. In this patient a soft vascular round celled sarcoma grew from the ethmoid involving the antrum and the frontal and sphenoid sinuses. The whole facial wound suppurated afterwards and the hole is seen opposite the inner canthus of the eye and deformity is seen below, due to removal of the orbital plate and subsequent dropping of the eye. This opening will have to be closed by a plastic operation.

bone be fixed to the nasal septum or to the nasal process of the frontal bone. I have carried this out in a recent case with success.

In some cases it is quite possible to save the palate when the comfort of the patient and the rapidity of his recovery are correspondingly increased.

In other cases a good result can be obtained by reflecting the mucoperiosteum of the palate inwards to the middle line and suturing this to the cheek flap after removal of the bone.

But the advantages of a foramen in the palate cannot be overlooked—it enables the whole operation area to be open to inspection; it facilitates free drainage and allows efficient dressing after operation. I am convinced that in the majority of cases it is both advisable and necessary to leave this opening, for a view is obtained stretching from the frontal sinus to the back of the sphenoidal cavity and from the pterygomaxillary fossa to the pharynx. A recurrence can be readily detected and exterminated with precision.

In regard to dental restoration a few words will suffice. A few days before operation a plaster cast must be taken of the patient's mouth by a dental surgeon interested in this work (*Fig 133*). A temporary denture can be fitted within a few hours of operation (*Fig 134*) greatly facilitating the feeding of the patient and mitigating his discomfort. Such a splint should have a bulbous extension upwards roughly to fill up the cavity of the antrum and keep the cheek out in its normal position. A final denture is fitted after a few months.

Space does not permit me to go into the details of plastic restoration. If adhesions have already taken place below the eye they should be fixed and a stent epithelial mould inserted and the cheek flap kept up by a denture.

The disfiguring hole at the inner angle of the orbit can be remedied by swinging up a portion of the upper part of the septum, and fixing it in position. In a short time this should be covered with epithelium, or a plastic skin-flap be turned down from the scalp. More extensive plastic efforts are required when the skin of the face has been removed and each case must be planned out according to its special requirements. It is a fundamental point that no plastic operation to cover a disfiguring hole should be undertaken until all reasonable danger of recurrence is past, and the whole cavity should be freely open to inspection for at least a year after operation.



FIG. 133.—Plaster case taken from the mouth before operation. In the first place the mould was taken in wax and the plate made from this to represent the plaster case of the mouth itself.

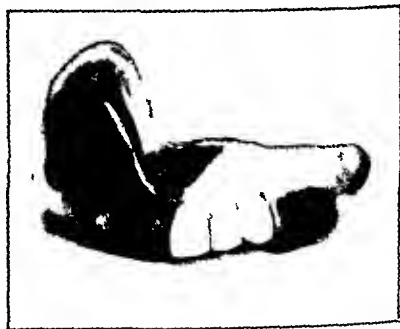


FIG. 134.—Temporary dental splint. This is made of vulcanite with a bulbous extension reaching into the cavity resulting from removal of the jaw. This can be inserted within forty-eight hours of operation and enables the patient to take his food.

RESULTS

Mortality—During late years the mortality of this operation has shown a remarkable decrease. In view of the extensive removal of tissue of the division of large sensory nerves near their ganglia, of the loss of blood and of the septic wound which overhangs the an-passages and sometimes involves the food tract this is extraordinary. It is I believe due to the use of intratracheal ether.

Table II—MORTALITY STATISTICS

OPERATOR	NO. OF CASES	NO. OF DEATHS	PERCENTAGE
Butlin	2	2	100
Göttingen Clinic	84	17	20
Harmer	23	2	8.5
Mollison	17	1	6
Davies	21	0	0
Woodman	30	0	0

Growths arising primarily in the retropharyngeal space and extending into the nose or superior maxilla from behind come into a different category, and often are best approached from the mouth by reflexion of the palate, though on some occasions they can very easily be removed by primary resection of the superior maxilla. The operative mortality of these growths is considerably higher than that of growths arising in the superior maxilla or an sinuses, and this is probably due to the presence of a septic wound overhanging the air tract. In my own series I have had three deaths from septic pneumonia or sepsis extending down the neck.

Recurrences—In a fairly large proportion of cases there are recurrences. There are two ways in which malignant tissue can be left *in situ*. The whole of the growth may not have been exposed—such, for instance, as an extension into the frontal sinus—and for this I can offer no excuse. In the second place, some implantation of cancer cells or infected blood is likely to take place over the raw surface of the flaps in the best planned operation, and this is unavoidable.

I feel sure that improving technique will produce just such an improvement in the statistics of recurrence as has already taken place in those of mortality, and that at no distant date.

If the operation be so planned as to leave the whole sinus area open to free inspection, the seriousness of a recurrence is reduced to a minimum. Unlike the recurrence of cancer in any other part of the body, the implantation deposit is less serious and more easily cured than the primary disease.

Table III—RECURRENTS

NAME	NO OF CASES	TYPE OF GROWTH	RECURRENT	NOT TRACED
Mollison	17	Carcinoma 14 Sarcoma 3	16	— —
Humei	23	Carcinoma 18 Endothelioma 5	16 5	— —
Davies	21	Carcinoma 10 Endothelioma 7 Sarcoma 4	6 0 4	— — —
Woodman	30	Carcinoma 8 Endothelioma 6 Epithelioma 8 Sarcoma 8	3 1 4 2	1 0 2 2

CONCLUSIONS

1 The pathology of the neoplasms of the upper jaw is not yet clear, but there is a high degree of local malignancy in nearly all types

2 The operation to be employed for removal of disease in the upper jaw should be modified to suit the case—it should be based on an intimate knowledge of the anatomy of the an sinuses and a sound surgical technique together with a close study of the disease in the patient to be dealt with

3 Intratracheal ether as an anæsthetic has great advantages and will replace laryngotomy

4 While mortality has been reduced to a minimum, recurrence is still an ever-present fear The operation should be so designed as to facilitate inspection and the eradication of recurrent growth, and no attempt at plastic repair should take place until this fear is dispelled

THE CLOSURE OF THE SUPRAPUBIC URINARY FISTULA FOLLOWING SUPRAPUBIC PROSTATECTOMY: OBSERVATIONS ON 68 CASES.

By H. P. WINSBURY WHITE, London.

THE 68 cases which are dealt with in this paper are from a series of 77 consecutive cases operated upon at St. Peter's Hospital between April and November 1921, of the 9 cases not included none survived convalescence.

The purpose of this paper is to consider (a) All the factors which have a possible influence on the time of closure of the suprapubic urinary fistula and (b) The utility of the in-dwelling catheter.

The subject is dealt with under the following headings: (1) Brief outline of post-operative treatment. (2) Division of cases into groups in relation to the employment of an in-dwelling catheter. (3) The use of the in-dwelling catheter. (4) The operative procedures. (5) The onset of micturition. (6) The time of removal of the suprapubic drain. (7) Secondary hemorrhage. (8) Malignant cases.

1 Brief Outline of Post-operative Treatment—The perineal and bladder wound is closed round Fiebert's tube¹ at the end of the operation and in some cases a small drain is inserted into the prevesical space. Fiebert's tube is left draining the bladder for three or four days and then replaced by a smaller one.

Urine is drained into suprapubic cellulose dressings¹ maintained with a many-tailed bandage. The dressings are changed four-hourly. When the prostatic cavity is packed at operation the gauze is removed on the third day. Daily irrigation of the bladder and prostatic cavity is carried out by the suprapubic route and by Janet's method². On the tenth day, the suprapubic drain and sutures are removed and a large steel sound is passed per urethram. The patient is sitting up out of bed during the third week in an uncomplicated case. Or an in-dwelling catheter is used when advisable. The patient is discharged from hospital when the fistula has closed.

2 Division of the Cases into Groups in relation to the Employment of an In-dwelling Catheter—The following classification has been found convenient—

Group I—All cases whose fistulae were finally closed by the twenty-eighth day without an in-dwelling catheter.

Group II—All cases showing signs of delay in closure of fistulae subdivided as follows: (a) Treated with in-dwelling catheter, (b) In-dwelling catheter contra-indicated for the time being. The cases under (b) terminated in one of two ways: (i) Spontaneous closure in due course, (ii) Closure following the delayed use of an in-dwelling catheter.

Into *Group I* fell 38 per cent, the average number of days required for closure being twenty, the earliest occurred on the thirteenth day.

The cases under *Group II (a)* were treated with an in-dwelling catheter for three days at some period during the fourth week of convalescence. There were 28 cases—about 41 per cent. The result in 19 cases (67 per cent) was complete closure of the fistula before the twenty-eighth day, of the remaining 9 cases it is interesting to note that 6 had not commenced micturition up to the time the catheter was tied in. The use of the catheter in such cases will be referred to later.

Group II (b) refers to those cases which would have benefited by an in-dwelling catheter but which showed some contra-indication for its use. They were 13 in number, or 20 per cent of the total. As already mentioned these terminated either by closing spontaneously, or not until after the delayed use of the in-dwelling catheter. Of the 13, 8 (about 61 per cent) subsequently closed without an in-dwelling catheter, the average period being thirty-seven days, 5 (about 38 per cent) were delayed until a catheter could be borne with safety, the average number of days before closure being thirty-four. It will be noted that the fistulae of the cases in which the in-dwelling catheter was used closed sooner than the others, thus demonstrating its value.

The following were the conditions which supervened and prevented or delayed the use of an in-dwelling catheter: (1) Acute epididymitis, (2) Pyelonephritis, (3) Slough or phosphatic deposit on the wound surfaces. By far the commonest of these was acute epididymitis, accounting for 7 of the 13, about 54 per cent. The part played by acute epididymitis in determining delay depended on whether the complication supervened early or late in the convalescence. If the former, there was not necessarily a contra-indication for the catheter by about the fourth week. In a previous paper entitled "Epididymitis and Suprapubic Prostatectomy—a Study of 50 Cases", the writer³ showed that 64 per cent of acute cases occurred during the first week of convalescence.

In the few cases in which an in-dwelling catheter was tied in the presence of some degree of pyelonephritis, the result was always to increase rather than diminish the signs of infection. It was therefore found more satisfactory in such cases to dispense with the catheter entirely.

With regard to slough or phosphatic deposit on the wound surface, in a few cases a coating of phosphatic deposit occurred. It appeared early, and commenced to peel off as a fine slough about the end of the third week. An in-dwelling catheter could serve no useful purpose until the granulations were free from slough. Moreover, these cases were rather prone to acute epididymitis and pyelonephritis. In other cases it was unusual for the part of the parietal wound closed by suture not to heal by first intention. The open portion generally showed healthy granulations by about the seventh day. Two-stage prostatectomy cases, however, were an exception to healing by first intention, as the wound invariably broke down in the subcutaneous area.

3 The In-dwelling Catheter—The ideal sought and encouraged was undelayed closure without the aid of an in-dwelling catheter, but in many cases where fistulae persisted without giving any indication of closing, this was established at once by a judicious use of the catheter, and again, in

cases of delay in recommencing micturition the in-dwelling catheter to establish the habit which was essential before closure would occur.

The reason for avoiding the use of the catheter if possible is that it is a foreign body in the urethra and granulizing prostatic cavity and in the presence of already existing sepsis tends to increase it.

The urethritis set up appears to be in proportion to the length of time the catheter is retained. No amount of care can prevent a purulent discharge from the urethra which has borne a catheter for six days. The discharge is serious until about the third day. By prolonging unduly the use of an in-dwelling catheter in the hope of providing an efficient dependent drainage it should be borne in mind that the value of the procedure is being minimized to some extent by the inevitable sepsis which results from the presence of the catheter in the urethra. In this series of cases the practice was followed of removing the catheter at the end of the third day in none of these cases did any complication arise. On the other hand it is not difficult to produce acute epididymitis by leaving a catheter in position for a week. Moreover the vesical end of the catheter becomes coated with urinary salts.¹ In order to get the maximum benefit in the minimum of time it is essential that the catheter be not resorted to too soon. When any doubt arose as to whether a case was ready for an in-dwelling catheter it was generally advisable to postpone its use for a day or two. Employing the catheter too soon means leaving it in position longer than intended. A urethritis is thus set up which might have been avoided. Any question of the fistula becoming epithelialized in the meantime was safeguarded by cruetting it with a sharp spoon while drawing together the edges of the wound with adhesive plaster was helpful in bringing about closure in many cases.

Before final closure of the fistula can be accomplished by the use of an in-dwelling catheter it is necessary that the wound surface be free from slough or phosphatic deposit and that micturition be re-established.

These factors being present then the most favorable moment is when the fistula remains dry for an hour or more at a time. In such cases closure from an in-dwelling catheter can be relied on. On the other hand it may be said that once a case has reached the wet and dry stage spontaneous and final closure is imminent and the catheter is not required. This was certainly so in some cases, but in several where an in-dwelling catheter was contra-indicated for other reasons the fistula remained open for a considerable time subsequently in spite of these indications. The plan followed therefore was to resort to the catheter if spontaneous closure had not occurred after several days of this stage provided there was no contra-indication for so doing.

Where the spontaneous onset of micturition was delayed it was essential to resort to the in-dwelling catheter. In some this was done when micturition had not commenced by the twenty-first day but in no case did final closure of the fistula result after removing the catheter until it had been used a second time following a week's interval of rest for the urethra.

Fistulae most obstinate in closing even after the use of an in-dwelling catheter were noted in the following cases. (1) After the second stage of prostatectomy when preliminary cystostomy had been performed several

months previously and when a cicatrized fistula remained, (2) Where re-establishment of micturition did not occur until after the use of the in-dwelling catheter

Gum-elastic coude, ranging from 18 to 22 French scale, were the catheters employed. The largest size was always used where possible, as it provided the best drainage. It was seldom that one so small as a No. 18 had to be employed, and such cases always required a good deal of attention, as the narrow lumen easily became blocked. When this occurred the only satisfactory way to deal with it was to remove the catheter and replace it by another. Obviously, all the good intended from the catheter may be lost if it is allowed to remain blocked for several hours, as the increasing intra-vesical pressure may cause the fistula to re-open. It was essential for the success of this part of the treatment to make frequent inspections and irrigations.

4 The Operative Procedures—These embraced three types of operation (1) Freyer's operation, (2) Thomson-Walker's operation, (3) Two-stage prostatectomy.

One or other of the first two methods was employed in 81 per cent of the cases, and on an average the fistulæ in these cases closed on the twenty-sixth day. In the remaining 19 per cent, prostatectomy was performed in two stages, the fistulæ closing on an average on the thirtieth day, but the slower cases were by no means all in the last group.

With the more tardy ones the question naturally arose whether the delay was due to any obstruction to the outflow from the urethra. In several of these, on passing a metal sound per urethram, an obstruction could be made out between the prostatic cavity and the bladder.⁶ In all of these cases Freyer's operation had been performed. As it did not fall to my lot to pass the sound in all cases, I cannot give the actual figures.

In two-thirds of the total number of cases operated upon Thomson-Walker's operation⁶ was performed, which entirely eliminated the possibility of obstruction.

In the two-stage cases the intervals between the cystostomy and the removal of the prostate covered periods varying from two weeks to eight months. Two cases had prostatectomy as long as eight months after cystostomy, and, as would be expected in each the fistulous track was considerably fibrosed at the time of operation. One took eight weeks and the other nine weeks to close.

5 The Onset of Micturition—Apart from several exceptional cases, micturition did not recommence until several days after the suprapubic drain had been removed. The practice followed was to remove it on the tenth day unless there was an indication for continuing the drainage a little longer.

As stated by Sir John Thomson-Walker⁷ "Occasionally there is a rise of temperature when the patient first passes urine through the urethra, but this subsides on the following day." This was noted in a number of cases.

For the whole series the nineteenth day was the average on which micturition commenced. In 60 per cent spontaneous micturition commenced by the twenty-first day. In 25 per cent spontaneous micturition was delayed

until some time during the fourth week. In 14 per cent there was no micturition until an indwelling catheter had been used. One case was as late as the thirty-fourth day in commencing and then only after an indwelling catheter had been employed. In two cases micturition was established on the day following the removal of the suprapubic drain.

In backward cases the use of the indwelling catheter undoubtedly helped to establish the habit. In one, however, it was not successful until after the use of the catheter for the second time. It was demonstrated that the slow return of micturition was one of the most important factors in connection with delay in closure of the fistula. It must be obvious that the final closure is impossible until micturition is re-established. Moreover, acute retention occurred in 2 cases whose fistula suddenly closed before micturition had commenced. They were treated with the indwelling catheter. With regard to the causes of the late onset of micturition it was found that in 2 cases some obstruction to the passage of a sound was manifested between the prostatic cavity and the bladder. In about 90 per cent of those cases, however, with micturition delayed towards the end of the fourth week there was one or other of the two following factors present in the history: (1) Symptoms of enlarged prostate for several years. (2) Marked chronic retention of recent origin. The inference is that loss of tone of bladder muscle from chronic retention was the chief cause of delay.

6 The Time of Removal of the Suprapubic Drain—In 7 of the earliest cases of the series the drainage tube was removed on the seventh day. The motive for early removal was the hope of thereby shortening the convalescence. The average number of days before final closure of the fistula in these cases was twenty-eight, whereas the average for a similar number of cases whose tubes were removed on the tenth day being treated at the same time was twenty-one. Thus the object of early removal appears to have been defeated. It is an advantage to continue the drainage until the granulations in the prostatic cavity are well formed. There was a very striking tendency to unsteadiness in the temperature in those cases where early removal was practised. Preyer points out that patients who pass urine early in the convalescence often do badly.

7 Secondary Hæmorrhage—This occurred in 1 case, about 6 per cent. In each case owing to the state of the urinary tract the patient was a poor subject for operation. The bleeding occurred at varying periods between the eleventh and the twentieth days. In no case was the hæmorrhage so severe as to cause any real anxiety. Each was treated by displacing the clots from the bladder with irrigation by Janet's method after dilating the fistula so that the large-size tube could be replaced and this was left in position until all signs of bleeding had ceased. It is important to recognize that to deal effectively with this complication the bladder must be emptied of clot, otherwise the contractions set up by its presence will cause the hæmorrhage to continue. Hæmostatic serum and morphia hypodermically were useful aids.

8 Malignant Cases—There were 7 of these—10 per cent of the total. All were early and recognized clinically before operation except one and all offered some prospect of relief by prostatectomy. In 2 cases the enucleation

was accomplished with the forefinger. With the other 5 the removal was only completed with sharp dissection, after placing the patient in the Trendelenburg position. The average number of days in closing for 6 of these was twenty-one, the other case was discharged with a permanent suprapubic drain. Although the 6 cases closed so readily, 5 of them reported back to hospital within a few months with the fistula re-opened.

SUMMARY

1 Too early removal of the suprapubic drain by diminishing the drainage too soon, tends to delay convalescence.

2 Rapid closure of the fistula is not always desirable.

3 Closure of the suprapubic fistula without an in-dwelling catheter should be the aim for all cases. This was accomplished in about 52 per cent of the cases, and in 38 per cent by the twenty-eighth day of convalescence.

4 The in-dwelling catheter is necessary in a large proportion of cases to avoid an unduly protracted convalescence. It was employed in about 48 per cent.

5 The in-dwelling catheter does not help the fistula to close if used too soon, it increases the amount of sepsis present if left in too long. No complication arose from its use for three successive days in any case of this series.

6 In a considerable majority (about 66 per cent) the fistulae were finally closed, either with or without the aid of an in-dwelling catheter by the end of the fourth week.

7 In the remaining cases the chief causes of delay in closure were (a) Complications preventing the use of an in-dwelling catheter such as acute epididymitis and pyelonephritis, (b) Delayed onset of spontaneous micturition, most commonly in cases of previous chronic retention, (c) Long-standing suprapubic fistulae in two-stage prostatectomy cases, (d) A shelf of mucous membrane between the bladder and the prostatic cavity in some cases after Freyer's operation of prostatectomy.

8 Secondary hæmorrhage is not, as a rule, a serious complication and can be readily controlled without operative interference.

9 The fistulae in malignant cases may close very readily following suprapubic prostatectomy, but tend to re-open within a few months.

I have to thank the staff of St. Peter's Hospital for permission to publish these notes.

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SHORT NOTES OF RARE OR OBSCURE CASES

ACUTE HÆMORRHAGIC PANCREATITIS: A CASE PRESENTING CERTAIN UNUSUAL FEATURES.

R. A. G. IMPRUIT FISHER, F.R.C.S.

The occurrence of more than one attack of acute pancreatitis in the same individual must be rare considering the fact that in the series in which two attacks occurred operated by an expert surgeon, both of which were treated by successful operation, the possibility of such extreme rarity is to justify detailed description.

W. H., age 58, a lighterman, was admitted to the St. George's Hospital, Greenwich, on March 6, 1923, complaining of severe abdominal pain. He stated that he went to bed feeling perfectly well, but that at 8 a.m. the next morning he was seized with violent pain in the upper part of the abdomen shortly after awaking. The pain was cramping and sharp at first, but in nature it was continuous although marked by fluctuation and remained fairly localized. He made no complaint of pain in the back. He vomited once soon after the commencement of the pain, and there were two movements of the bowels within half an hour of its onset, once which there had been no action. He was seen by his doctor, who ordered his removal to hospital.

Previous History. The patient, until his recent entry of admissions to hospital, had enjoyed excellent health and was of temperate habits. His digestion had been good, and he had never been troubled with constipation. He had never been jaundiced or suffered from colic. He had been an in-patient at the hospital on three separate occasions in the preceding year.

1. He was admitted on Nov. 8, 1921, with a fracture of the neck of the right femur, and discharged on Jan. 6, 1922, with good function.

2. On May 5, 1922, he was operated upon by my colleague, Mr. F. F. C. Milligan,* for acute hæmorrhagic pancreatitis of which he presented the classical signs and symptoms. Violent epigastric pain commenced at 10 p.m. on May 4 and the operation was performed at 8.30 p.m. on the following day. At operation Mr. Milligan found much dark blood in the general peritoneal cavity, particularly in the right kidney pouch. The lesser peritoneal sac was also full of blood. The pancreas was swollen and dark purple in colour, and

* I am indebted to Mr. Milligan for the notes of the condition found at operation.

the body of the gland contained extravasated blood. There was fat necrosis of the omentum. A tube was introduced below the stomach into the lesser sac. At first there was a blood-stained discharge, later, this became purulent, and continued for some time. Some digestion of the abdominal wall occurred, which, however, ceased on the application of dilute acetic acid dressings. A pathological investigation of the faeces on May 11 revealed no excess of free fats but fatty acid and soap crystals were present. A twenty-four-hour specimen of the urine showed the presence of 5 units of diastase. He made a good recovery, and left the hospital on July 13.

3 He was next admitted on Oct. 19, 1922, with a simple transverse fracture of the right patella with but little separation of the fragments. This was treated by non-operative methods, and he left hospital to attend as an out-patient on Nov. 27. He made a good functional recovery and as I signed his discharge certificate I expressed the hope that his series of admissions to hospital had now come to an end. But the Fates ordained otherwise and he was admitted, as already mentioned, with a second attack of acute hæmorrhagic pancreatitis.

CONDITION ON ADMISSION.—The patient, a somewhat stout well-nourished middle-aged man, presented the signs and symptoms of an acute abdominal catastrophe of the upper abdominal type. A considerable degree of collapse was present: the skin was cold and clammy, the pulse rapid and of poor volume and the temperature subnormal. A striking feature was a peculiar leaden colour of the skin, with a definite cyanotic tinge of the lips and face. He was restless and complained much of thirst. Pain was extremely severe and situated in the epigastric region and in the upper left quadrant of the umbilical region, the pain being more marked at the latter site. As already mentioned it remained localized and did not penetrate to the back but was subject to exacerbations. The abdomen was generally distended, the distention being more marked above the umbilicus. Abdominal tenderness was marked in the epigastric region but the abdomen moved slightly on respiration and there was a complete absence of the board-like rigidity which is usually associated with such acute upper abdominal catastrophes as ruptured gastric or duodenal ulcer. He was troubled with a cough, and the expectoration was 'rusty' in appearance. Examination of the chest revealed dullness to percussion of both lung bases with moist crepitations. The presence of cyanosis and the absence of board-like rigidity in conjunction with the other signs and symptoms—although I was at the time unacquainted with the patient's previous history—influenced me considerably in arriving at a diagnosis of acute hæmorrhagic pancreatitis, although it was clear that serious trouble existed above the diaphragm in addition.

Unfortunately it is considered by some that the presence of a most unyielding type of *generalized* abdominal rigidity is characteristic of acute pancreatitis but this is not borne out by my personal observations of this and other cases. Extreme rigidity localized in the epigastric region, with a somewhat flaccid abdominal wall elsewhere, may, however occur. Moynihan¹ states: "The abdomen, when examined early presents the most indomitable rigidity and some fullness in the upper part: the remaining parts may be quite soft and flaccid, yielding readily to the hand, or they may be

the operation, after which the discharge promptly ceased. His condition rapidly improved, and he was sent to a convalescent home.

The occurrence of suppuration followed by sloughing of pancreatic substance points to the fact that the three forms of acute pancreatitis described by Fitz—viz, hæmorrhagic, suppurative, and gangrenous—may, as Moynihan points out, be different stages of the same disease.

Commentary—The experience of this case has strengthened in my mind the impression I had already obtained that acute pancreatitis presents a definite clinical picture, and that diagnosis should be possible by attention to certain distinct features. It seems clear that many text-books instead of endeavouring to point out its peculiar distinguishing features, are too apt to attempt to bring it into line with other abdominal catastrophes.

Most of us are familiar with the dicta of Fitz,⁴ a pioneer upon this subject who wrote: "Acute pancreatitis is to be suspected when a previously healthy person or sufferer from occasional attacks of indigestion is suddenly seized with violent pain in the epigastrium, followed by vomiting and collapse, and, in the course of twenty-four hours by a circumscribed epigastric swelling, tympanic or resistant, with slight rise of temperature." And again: "The symptoms are essentially those of a peritonitis beginning in the epigastrium and occurring suddenly during ordinary health without obvious cause."

Let us analyse these statements a little more closely and inquire whether recent advances have not provided us with a somewhat clearer picture. In the first place, it may be stated that nowadays it is unlikely that anyone would wait twenty-four hours, in the presence of the acute symptoms mentioned for the occurrence of 'circumscribed swelling' in order to confirm a possible diagnosis of acute hæmorrhagic pancreatitis. The remainder of the clinical picture applies with equal accuracy to a number of acute upper abdominal conditions, and is by no means pathognomonic of acute hæmorrhagic pancreatitis. In my experience, the collapse, pallor or cyanosis, restlessness, thirst, increasing abdominal dullness and distention, and absence of board-like rigidity, point to intra-abdominal hæmorrhage rather than to peritonitis. The violent nature of the pain is, of course, explicable by the position of the primary source of the hæmorrhage which causes extreme stretching of the parietal peritoneum covering the pancreas, and the profound collapse by the proximity of the solar plexus. I think therefore we are in a position to modify the otherwise excellent description of Fitz and to state: "Acute pancreatitis is almost certainly present when a person is suddenly seized with violent pain in the epigastrium followed by vomiting, severe collapse, and cyanosis, and by the symptoms of intra-abdominal hæmorrhage, unassociated with typical peritoneal rigidity."

Second Attacks of Acute Hæmorrhagic Pancreatitis—The occurrence of two attacks must be a very rare condition. I have been able to find a record of only one such case and in this death occurred during the second attack. The case is recorded by Dick² as follows:—

'A. B., male, age 44, a publican, was well known to me prior to his present illness and was definitely alcoholic in his habits. I was called to see him on April 12, 1905, and found him in bed suffering from epigastric pain, obviously

very severe. The pain was constant but with paroxysmal exacerbations and its severity was of a degree altogether exceptional. He showed signs of profound shock there was general clummy pallor and his pulse was hardly to be felt. Temperature 97.4°. On inspection of the abdomen there was some limitation of movement on respiration but this was not pronounced. On palpation there was no well marked general tenderness in the epigastrium and no definitely localized tender spot. Steady pressure tended to relieve the pain. The condition appeared to me to be unusually severe biliary colic although I had never from previous experience known him to be harbouring gall-stones. A full dose ($\frac{1}{2}$ gr) of morphia was given hypodermic dly. but to my great surprise failed to give any relief. $\frac{1}{2}$ gr was therefore given an hour later again without relief. The pain and collapse were unaffected.

"On the second day of the illness the condition was the same with certain symptoms added—notably great restlessness and intense thirst. The former was very noticeable, and it was in altogether unusual thing to see a man so profoundly ill—with no pulse at the wrist and collapsed—attempting to get out of bed apparently with the idea of getting relief from pain by change of posture. Once again morphia failed to relieve, although repeated until 1 gr had been given hypodermic ally in twenty-four hours, the initial dose being again $\frac{1}{2}$ gr. There was considerable nausea with occasionally small quantities of bilious vomit, but vomiting was at no time a striking symptom.

"On the third day there was to be observed some circumscribed swelling in the epigastric region above the umbilicus. There was complete constipation but flatus could be passed, and there were not present the signs of intestinal obstruction. By now it was borne in upon me that I was witnessing a combination of clinical symptoms which I had never previously seen and constituting to me a new disease.

On the fourth day the severity of the symptoms as regards pain and collapse had slightly abated, the pulse returned at the wrist and was feeble rapid (112) and of low tension. Temperature 98.8°. Still no action of the bowels.

"Fifth day and afterwards. Improvement was gradually maintained. The bowels were moved on the seventh day, a large greenish slimy evacuation.

"On the tenth day he was able to be out of bed and, although very weak, was comparatively well.

"This initial attack lasted from April 12 to 21.

"SUBSEQUENT HISTORY FROM APRIL 20 TO JUNE 21.—After April 20 he gradually recovered strength, and resumed his ordinary occupation. The only persisting symptom which I noted was *pain in the back* brought on by stooping while working in the garden. The pain was in the lower dorsal region, and not acute—more of a dull ache—and always brought on by continuous stooping. On June 20 I was again summoned, and found him in acute pain and collapse, which lasted for twenty-four hours and terminated fatally, all palliative treatment being again unavailing. The symptoms were identical with those occurring on April 12.

"POST-MORTEM EXAMINATION.—The abdomen only was investigated. There was no general peritonitis. The liver showed signs of the early fatty stage of cirrhosis. The gall bladder contained no gall-stones nor were any to be found in the cystic and common ducts. The fat in the root of the mesentery and omentum was here and there converted into soft lumps of the consistency of butter. The lesser sac of the peritoneum was distended and full of turbid chocolate-coloured fluid, and floating free in this fluid were dark lumps of old and recent blood-clot, and tougher masses consisting of gangrenous pancreatic tissue. The pancreas was disorganized, parts of it were soft and pulpy, other parts tough and indurated, there were areas showing old and recent hæmorrhage.

"Microscopical Examination of the Pancreas.—Difficulty was experienced in securing a portion of the gland which was not hopelessly necrotic, for microscopical examination. On examination, however, early and later inflammatory changes were found the former evidenced by small-celled infiltration, and the latter by overgrowth of fibrous tissue. Crystals of hæmatin were distributed throughout the specimen. The glandular element showed great disintegration, part of which may have been due to post-mortem changes."

Etiology—Controversy raged for many years around the question as to whether the pancreatic hæmorrhage was primary, or whether some inflammatory condition of the pancreas preceded and caused the hæmorrhage. The consensus of opinion in modern times appears to be that both modes of origin may occur. Fitz certainly inclined to the view that hæmorrhage might be directly causative. Mayo Robson considers that the ultra-acute type is probably due to a primary hæmorrhage whereas in the cases with somewhat less acute symptoms, the hæmorrhage is preceded by inflammatory processes in the pancreas. Everyone is familiar with Opie's classical experiments. Unfortunately the question is still in the realm of hypothesis and cannot yet be said to rest upon a scientific foundation. Possibly the primary hæmorrhage factor has been exaggerated. Certainly we know that the hæmorrhages that occur in the pancreas after trauma, in certain abnormal blood conditions in infectious diseases, heart disease, and atheroma, are not necessarily followed by acute pancreatitis.

To return to the case under consideration the absence of gall-stones and of any symptoms suggesting an infective condition of the alimentary tract is of interest, yet the presence of the coexistent infective foci in the lung bases is of still greater import, and strongly suggests that the pancreatitis was also infective in nature.

It is interesting to note, that in spite of the necrosis of a large part of the body of the pancreas that undoubtedly occurred, the patient presents no signs of pancreatic insufficiency.

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A CASE OF JEJUNAL DIVERTICULA

By L. R. BRAITHWAITE, LEEDS

THE following case presents a condition of such rarity that it merits publication.

J. H., age 54, was brought to my notice by Drs Taylor and Harlowell on March 3, 1917, as a case of chronic intestinal obstruction probably due to old tuberculous peritonitis. I diagnosed the condition as one of atonic dyspepsia, advising lavage and an X-ray examination. The following is a copy of Dr Rowden's report dated March 8, 1917—

X-RAY EXAMINATION—Stomach Is somewhat dilated. Tone good. Outline regular. Peristalsis active, and the waves are seen to pass along greater and lesser curvatures right up to the pylorus. It is about one-half empty in one and a half hours, and completely so three hours after the opaque meal. No X-ray evidence of gastric ulcer. No pyloric obstruction.

"Duodenum" No food lodges. Pyloric cap not visible. No evidence of duodenal ulcer.

"Small Intestine" In several places (three or four) the food accumulates in sacs or pouches in the region a little to the left of the umbilicus. These are probably in the jejunum or proximal portion of the ileum. Beyond these pouches there is partial obstruction probably due to bands or pressure of enlarged mesenteric glands. In spite of these 'obstructions' some of the meal has arrived at the caecum in five hours.

I did not see the patient again until Oct 31 1922 and at that time he presented very definite physical signs. There was obvious small-intestine peristalsis confined to the left half of the abdomen. His symptoms led me to



FIG 135—X ray examination Result 24 hours after opaque meal

suppose him to be suffering from tuberculous peritonitis, with subsequent adhesions and multiple obstructions in the upper half of the small intestine. I admitted him to the General Infirmary at Leeds with this diagnosis, and the following is a copy of his case-history and operation —

HISTORY—Patient admitted for pain and nausea after food. Present condition has lasted six years definitely. The patient on eating food feels a foul taste in the mouth immediately after the first mouthful. This is followed by formation of much wind, which is eventually passed as flatus or by the mouth. Moreover, there is a feeling of food retention in the lower part of the abdomen, which is relieved generally by taking another meal. Vomiting

used to take place three or four times a week, two or three hours after food, the vomit consisting of the food taken before, yellow in colour and acid in taste. Eighteen months ago hæmorrhage by the mouth occurred, consisting of some five pints of unaltered blood. It followed an ordinary vomit. After this the vomiting ceased. The patient has lost two stone in weight during the six years, he has generally been constipated. Micturition normal.

ON EXAMINATION—The abdomen is distended. Wall is somewhat tense. No definite pain on pressure. Marked visible peristalsis, confined to left half of abdomen.

OPERATION, Nov 9, 1922—Right rectus incision. The upper third of small intestine showed numerous (about fifty) diverticula, along its mesenteric



FIG. 136—Showing the portion of intestine removed at the second operation.

border, but bulging free into the peritoneal cavity. The largest was larger than a Tangerine orange, the smallest the size of a pea. Large diverticula showed inflammatory changes with adhesions. Some seemed to be almost on the point of perforation, the walls being white and extremely thin, like tissue paper. The first diverticulum was at the duodenojejunal flexure. The upper few feet of the small intestine were hypertrophied and dilated. Owing to the presence of the uppermost diverticulum actually at the flexure, excision was thought to be inadvisable. A lateral anastomosis was made between the antimesenteric border of the upper end of the jejunum and the intestine below the diverticula. Numerous enlarged glands were found in the mesentery of the jejunum, one was removed for examination. He made an excellent recovery from the operation, and on Nov. 20 an X-ray examination was made by Dr. Scargill, the result of which was inconclusive. The following

is the report by Dr Scargill " (1) Three hours after barium meal (2) Fifteen minutes after barium meal There is a retention of barium in the small intestine after most of it has passed into the lower coils but it is not possible to radiograph whilst the jejunum is filled

The result of the anastomosis was not good He was relieved in some measure, but began to suffer from attacks of pain vomiting and abdominal distention which indicated to my mind the filling of the diseased portion of the intestine by gas and traction of the distended loop on the duodeno-jejunal flexure giving rise to mechanical obstruction

An X-ray examination was now carried out by Dr Rowden *Fig 135* represents the condition found at this time and shows with extraordinary clarity many of the diverticula apparently filled with bismuth The horizontal line made by the bismuth as it lay in the diverticula is particularly well shown It is of interest that most of the bismuth found its way immediately through the new anastomosis and into the lower portion of the small intestine Only a small portion escaped along the natural path into the diseased portion of bowel

SECOND OPERATION — He was re-admitted to the Infirmary and a second operation was performed on March 28 1923 The uppermost diverticulum, which lay at the duodenojejunal flexure, was infolded The portion of intestine infected by disease, amounting to about four feet was then excised immediately below the existing anastomosis, and the divided ends were closed *Fig 136* is a photograph of the specimen He made an excellent recovery and has remained well since

The case presents features of great interest with respect to the radiographic findings It is remarkable to note that so early as July, 1916, on examination made by Dr Rowden, a definite diagnosis of pouching in the small intestine was made, and *Fig 137* is an exact copy of Dr Rowden's diagram made on that occasion

With regard to the operative procedure adopted the real difficulty in the case was presented by the uppermost diverticulum It was realized that to remove this diverticulum and the bowel contiguous to it would leave such a short end with which to make an anastomosis that the certain union of it would be in doubt The only procedure to be adopted would have been to close the upper end of the jejunum and do a gastro-enterostomy In the year 1914 I published in the *BRITISH JOURNAL OF SURGERY* three cases in which this procedure was adopted, but for a different condition

Eventually it was decided that the uppermost diverticulum might possibly be treated by infolding, rather than by excision, leaving sufficient

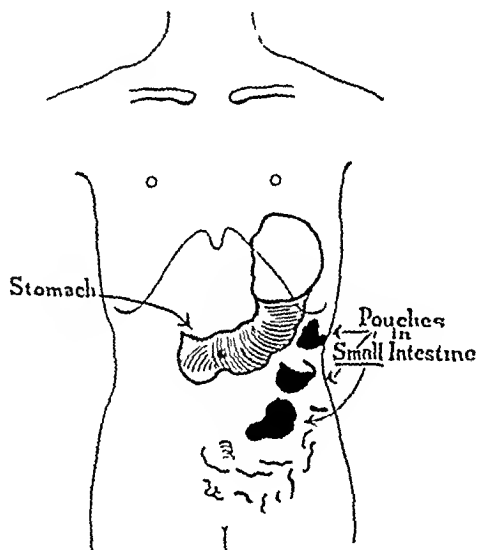


FIG. 137 — Condition about 1 hour after opaque meal Copied from the diagram made by Dr Rowden in July, 1916

intestine along its antimesenteric border with which to do an anastomosis. It is rather too early to say with any certainty whether the infolding operation as adopted can be of any permanent value. It is to be supposed that there will be some danger of an expansion of this diverticulum, with a chance of perforation.

Then with regard to the symptomatology. One would have anticipated that, owing to the filling of the multiple diverticula and traction therefrom, a state of acute intestinal obstruction would have been inevitable. The absence of this is possibly accounted for by the fact that the openings of the diverticula into the intestine were very small and most of the contents would pass along the canal. It would appear certain that after the first operation his symptoms were due purely to traction from a filling of the isolated loop with its diverticula.

It was considered that a personal narrative given by the patient himself would be of considerable interest. The following is a copy of his history as he described it—

"As far back as I can remember I have suffered more or less from dyspepsia. When 18 years old I had an accident in the cricket field, my right knee being put out. Until 35 years of age I suffered from periodical attacks of indigestion with much flatulence and pain in the stomach and bowels, and much vomiting. Often these attacks were accompanied with synovitis in the knee which caused great pain and inconvenience. From 35 to 45 years of age I was entirely free from synovitis and had very little indigestion, my general health being very good.

"In 1915 and during the War period I spent much of my time in London. The air raids, which were numerous, had an effect on my general health, the indigestion again appearing, and, in due course, the synovitis. After a meal I had an hour fairly comfortable, then a swelling of the body took place with much flatulence in the stomach and intestines. The wind noises made it very uncomfortable to sit in a room with other people, and often I had to retire to my own room until these noises subsided, which used to be in about two hours. After much retching the wind passed off in the natural downward way—then relief. When, however, the wind did not pass naturally violent sickness ensued.

"In 1916 I was examined by X rays (Dr Rowden—see Fig 137). In 1917 I experienced an obnoxious taste every time I had a meal. This taste generally subsided by the time the meal was finished, but eventually it was the cause of much trouble, and was diagnosed by a physician as septic poisoning from some cause which could not be found. In January, 1920 after a lunch of ordinary size, I had a violent attack of sickness followed by internal hæmorrhage, parting with about five pints of blood. Previous to this occasion I felt to be in good health. My teeth were suspected, and I had them all extracted in March, 1922. The taste was worse than ever afterwards. An operation was later advised, and took place in the Leeds General Infirmary in November, 1922 (see report). After this operation the bad taste disappeared, but other troubles, chiefly vomiting, presented themselves. A second operation was advised, and was carried out in March, 1923. To date, May 10, 1923, operation is working quite satisfactorily."

AN UNUSUAL CAUSE OF DEATH IN ACUTE APPENDICITIS.

BY C HAMILTON WHITEFORD, Plymouth

ON Feb 24 1923 a seaman age 21 was admitted to the Plymouth Infirmary with a history of ten days illness—intermittent abdominal pain—while at sea. The ship carried no doctor and details of this period of the illness were not available. The medical man who first saw the patient found no symptoms of acute abdominal disease.

Seen by the writer on the 11th day of the illness the condition was as follows. Patient sallow and rather thin with cough and râles in both lungs. Respiration 26, pulse 92, temperature 100°. He complains of intermittent abdominal pain in right side of abdomen and epigastrium. He states that he has lost flesh, and always has a cough and that the abdominal discomfort commenced about ten days ago. There had been no previous abdominal illness. The abdomen was retracted, not boarded and slightly tender along the ascending colon. No tumour was palpable. Per rectum there was neither tenderness nor tumour. Indications for immediate operation were not obvious, and the opinion was expressed that the symptoms could be explained by a pulmonary lesion (possibly tuberculous) with pain referred to the abdomen.

On the 15th day the leucocyte count was 17 000, respirations 30 pulse 90, temperature 99°. Abdominal tenderness as on admission. There had been no vomiting, and the bowels had acted after enemata. It was now ascertained that on the 10th day there had been a rigor lasting ten minutes and the patient stated that, during his illness at sea, he had several 'attacks of shivering'.

On the 16th day the respirations were 24, pulse 70, temperature 98.4°.

OPERATION.—Under the anæsthetic, a deep-seated resistance was palpable in the outer part of the right iliac fossa. The cæcum was exposed from its right side. The general peritoneal cavity was not shut off by adhesions, and was packed off with gauze. A tumour the size of a hen's egg was found lying to the right of and behind the cæcum, which formed part of the front wall of the tumour. The abscess was opened with the finger and one ounce of thick greenish-yellow pus spouted out. The pus was followed, at once, by a stream of dark blood which welled up from the abscess cavity. Half a pint of blood escaped. The abscess cavity was 'bipped' and packed with gauze which stopped the bleeding. A half-inch rubber tube was passed down to the gauze in the cavity. The appendix was neither seen nor felt. The gauze removed from the peritoneal cavity contained no blood.

Twenty hours after operation the respirations were 26, pulse 94, temperature 99°. The gauze was removed from the abscess cavity, and the tube was shortened. There was no recurrence of bleeding, and no more gauze was inserted. Twenty-seven hours after operation, the patient, while talking to his brother, collapsed, and died in five minutes. There was no bleeding from the wound.

AUTOPSY.—Permission was obtained only for examination of the abdomen through the incision. The abdomen was full of fluid blood and clots, none of which were adherent to or incorporated with the surfaces of the viscera.

The walls of the abscess were infiltrated with clot, and no opening could be demonstrated in the iliac veins. The abscess lay between the cæcum and the pelvic brim. The rest of the abdomen showed neither adhesions nor peritonitis. The appendix, three inches in length and gangrenous throughout, was still attached to the cæcum, which was not perforated.

Comment—The sequence of events appears to have been as follows. Acute inflammation and gangrene of a ileocolic appendix. Spread of infection to a vein (? external iliac) in the wall of the abscess. Septic thrombosis of the vein, with detachment of small emboli, which lodged in the lungs. Evacuation of the pus left the vein unsupported and the vessel ruptured into the abscess cavity. Gauze pressure closed the opening in the vein and permitted formation of a thrombus. The thrombus became softened or displaced, and blood poured from the vein into the peritoneum via the abscess cavity.

Disproportion between the respiration and pulse rates was a marked feature throughout, and may have been due to lodgement in the lungs of small septic emboli.

J. D. Malcolm (*Surgery, Gynecology, and Obstetrics*, Nov. 1908, p. 529) mentions four similar cases. Of these, two recovered after ligation of the external iliac artery, one recovered after the abscess cavity was packed with gauze and one "rapidly succumbed."

PERFORATION OF A MECKEL'S DIVERTICULUM. OPERATION RECOVERY

BY DOUGLAS DREW, LONDON

THIS case appears worthy of record, as the child was operated upon at the age of 10 months by Mr. F. J. Steward for an intussusception of a Meckel's diverticulum, the intussusception was reduced and the abdomen closed, as the age of the child and its serious condition did not permit of the removal of the diverticulum.

Mr. Steward has kindly supplied the following note—

I operated upon this patient at the age of 10 months for intussusception. On opening the abdomen the intussusception was found to commence at the junction of a Meckel's diverticulum with the ileum. The diverticulum was about 2½ in. long, and had advanced into the ileum a distance of about 3 in. The parts were considerably congested, and reduction was difficult, but was accomplished at the expense of several tears in the peritoneal coat of the ileum. The question of resection of the diverticulum was then considered, but was abandoned because the condition of the parts was such that resection of a considerable length of ileum with the diverticulum would have been necessary, and I did not think it wise to undertake this as the child was then somewhat collapsed. Recovery took place without incident.

No further trouble occurred until the boy was 9½ years old, when I was called to see him in consultation (August, 1922). He then had acute abdominal symptoms suggesting acute appendicitis—sickness, abdominal

pain and tenderness raised temperature rapid pulse and rigidity of the abdominal wall

The question was discussed as to whether the trouble might be due to the diverticulum and bearing this possibility in mind the abdomen was opened on the right of the umbilicus

The transverse colon small intestine and omentum were adherent around the umbilicus In separating the adhesions, a small collection of thick dark-green fluid resembling bile was evacuated After the adhesions had been freed the bowel was drawn outside and the omentum separated from the diverticulum which it enveloped The

diverticulum was flask-shaped about $1\frac{1}{2}$ in long by 1 in wide with a narrowed neck where it joined the bowel (*Fig 138*) this was clamped flush with the bowel, a catgut ligature applied and the stump buried with a purse-string suture There was evidence of early peritonitis with a quantity of slightly turbid and bile-stained fluid in the flanks and the pelvis, which was carefully sponged away the appendix, which was normal was removed A short coil of the small intestine, about six inches, in the middle of which

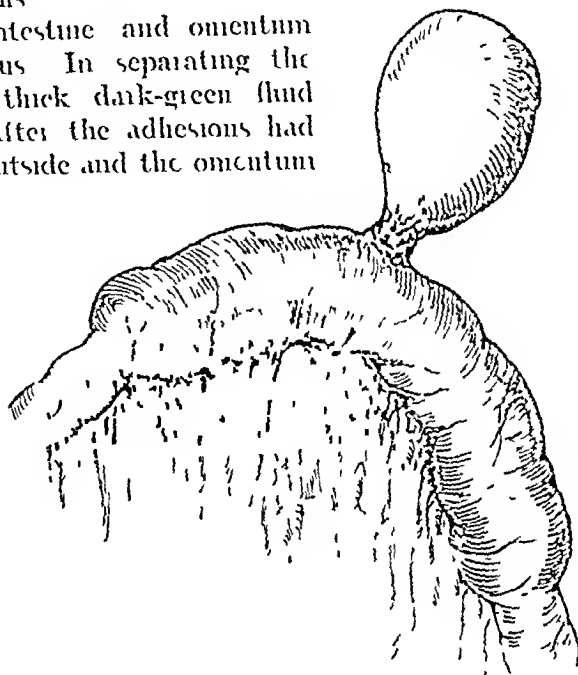


FIG 138 — Meckel's diverticulum proceeding from the middle of a portion of hypertrophied intestine

was the attachment of the diverticulum was very considerably hypertrophied the limits of the hypertrophy being quite sharply defined I decided against inserting drainage tubes, as the operation was performed within twenty-four hours of the onset of symptoms, and for the reason that in perforated duodenal ulcer in the early stages it is not necessary and the infectivity of the contents of the small intestine at the level of the diverticulum was not likely to be much greater than that of the duodenum

It will be noted that no mention has been made of a perforation for the reason that none could be discovered On careful examination of the diverticulum after its removal, the interior of the body of the flask was empty, and its mucous membrane did not show any sign of inflammation, but that of the neck of the flask was red and inflamed, no perforation however, could be found In the absence of a microscopic perforation due to an agent such as an undiscovered fish bone, I think that the peritonitis arose from infection spreading from the inflamed part of the neck, and was possibly determined by the diaphragm upon it by the hypertrophied part of the bowel

The case therefore, differs somewhat from a Meckel's diverticulitis as the pouch was empty and the mucous lining was not inflamed except as above stated

REVIEWS AND NOTICES OF BOOKS

A Text-book of the Surgical Dyspepsias By A. J. WALTON, M.S., M.B., B.Sc. (Lond.), F.R.C.S. (Eng.), Surgeon (with charge of Out-patients) London Hospital, late Surgeon Poplar, Greenwich, and Evelina Hospitals, late Hunterian Professor Royal College of Surgeons. 8vo. Pp. 728. 1923. London. Edward Arnold & Co. £2 2s net.

It is stimulating to find 'gall-stones' and 'chronic appendicitis' at last in a book entitled *The Surgical Dyspepsias*, not so much that these conditions are surgical, as that their inclusion emphasizes their symptomatology. Mr Walton's excellent book fills an undoubted hiatus, in that it embraces almost all the surgical abdominal conditions associated with dyspepsia, and gives the most carefully selected extracts in regard to their etiology and pathology; it fills a place which could only be furnished otherwise by a perusal of at least a dozen works or monographs of specialists' in the various dyspepsias.

Chapters I and II are invaluable in that they recite in detail the surgical anatomy of the stomach, and give a very careful account of the methods of examination of a case of dyspepsia. In Chapters III to VII the cause, diagnosis, and treatment of gastric and duodenal ulcer are adequately dealt with in the light both of modern research and the experience of the greatest workers. Pyloric stenosis is discussed in Chapter VIII, gastric neoplasms and their treatment in Chapters IX and X. On p. 211 the author dismisses in eleven lines that by no means rare condition "chronic duodenal ileus", and suggests no method for its cure. Rare conditions, e.g., foreign bodies and injuries of the stomach, acute dilatation, volvulus, and intussusception are sufficiently described in Chapter XI.

It is in connection with the technique of gastric operations and the operative treatment of gastric lesions (Chapters XII, XIII, and XIV) that one would wish to make some criticism. The author seems to suffer from his anesthetists. On p. 314 he says with reference to closure of the peritoneum and posterior sheath, "This will generally be found the most difficult part of the whole operation", and on p. 315, "If the patient be struggling considerably". Surely this is not the usual experience of surgeons.

The technique of performing gastrojejunostomy varies in different surgical clinics, but rigid surgical cleanliness should be common to all. Mr Walton, like so many other very brilliant and successful operators, is inclined to judge results rather on mortality than on the quality of the recovery. Surely before an incision is made into the lumen of the stomach and jejunum, some warning should be given that a potentially septic focus is about to be invaded, and some precaution be taken to avoid spread of the infective agent over the so far sterile pads.

In the treatment of gastric ulcer, pride of place is given to wedge resection, with a posterior gastroenterostomy and occlusion of the pylorus. Numerous authorities are quoted to support this line of treatment, and Mr Walton expresses himself as well satisfied with it. It is quite certain that this line of treatment is not nearly so successful as regards the late after-results in the hands of many others. Not only are symptoms likely to recur, but new ulcers to form, both in the site of the wedge resection and in the line of the gastrojejunal anastomosis. In addition, wedge resection cannot be considered sufficient for those cases, possibly not so rare as one may imagine, where malignant change is beginning to take place. It is for

partial gastrectomy one pleads in easier operation and in skilled hands more rapidly performed with a mortality little if any greater than that from simple gastrojejunostomy with a quality of recovery and a permanency of freedom from all symptoms as satisfactory as is achieved in the treatment of duodenal ulcer.

Chapters XV to XVIII deal with gall-stones and their complications. Following a lucid chapter on the surgical anatomy of the liver and gall-bladder the etiology and pathology of gall-stones are very well represented. One is pleased to find flatulent dyspepsia described as the earliest symptom of gall-stones and a strong plea made for early surgical treatment. The author gives a perfectly fair discussion of cholecystotomy versus cholecystectomy, and decides definitely—and in our view rightly—in favour of the latter. He makes the very true remark that a probe cannot be passed along the cystic into the common duct but suggests it is a simple matter after the gall-bladder is removed. One finds very frequently, however that unless the cystic duct is divided at its junction with the common duct (not a good thing to do if one is to place a ligature or suture upon it afterwards), the stump of the cystic duct that is left has to be slit up into the common duct before exploration of the common duct can be accomplished. As in gastric so in gall-stones work Mr Walton errs in his technique. There is not nearly sufficient care in shutting off the surroundings from the potentially infective bile, and by advocating a drain into the right renal pouch after simple cholecystotomy he would seem to admit his own doubts.

Chapters XIX and XX are devoted to the puereris. They are well written and quite sufficiently in detail for all practical purposes.

Chapters XXI and XXII are devoted to a consideration of visceral ptosis and appendix dyspepsia and their treatment. One could wish that less space were given to the former and more to the latter. It is surely notorious how unsuccessful the majority of operations for visceral ptosis are however certain it is that the symptoms are real enough. One could have wished the author had laid more stress upon the belt or support associated with his name.

As a whole, one welcomes the book very warmly, it is certainly a fine compendium for the senior student, it will be exceedingly useful for those in general practice who desire to know exactly what surgery is doing for dyspepsia, but it is not nearly an adequate technical work to guide the steps of a young surgeon.

Mr Shiell's drawings are clear enough, but some of them are crude. They do not suggest familiarity with the living subject, they compare unfavourably with the quality of work seen, for example, in the American books on similar subjects.

Die Knochenbrüche und ihre Behandlung. Ein Lehrbuch für Studierende und Ärzte.
By DR. MED. HERMANN MATTI, Privat docent für Chirurgie an der Universität und
Clinicus am Jenerspital in Bern. Royal 8vo. In two volumes. 1918 and 1922.
Berlin: Julius Springer.

Vol. I.—General Principles of Fractures and their Treatment. Pp. 395, with 420 illustrations. Unbound, 20s. Bound, 23s. 8d.

Vol. II.—Special Fractures, including Fractures of the Skull and Spine, together with their Complications. Pp. 985 + vi, with 1034 illustrations. Unbound, 50s. Bound, 53s. 4d.

There can be no doubt that this work represents a most important and valuable addition to the systematic description of fractures. The first volume deals with general principles. The opening chapters describe the incidence of fractures with relation to age, sex, and occupation, the architecture of bones, and the mechanics of fractures with relation to bony structure and the breaking force. These sections are clearly written and excellently illustrated both by diagrams and skiagrams.

The next section deals with the pathological anatomy and physiology of recent fractures, and is accompanied by very well chosen photographs of typical museum specimens. There is a special chapter on x-ray technique in fracture examination.

The remainder of the volume is chiefly occupied by a description and discussion

of the general principles of fracture treatment. Those which depend upon traction methods are very thoroughly dealt with, and especial stress is laid upon the importance of semi-flexion of the joints in abolishing muscle tension. Every possible traction device is described and figured, but many of these are too complicated for general use. Mention of the use and value of the Thomas splint is conspicuously omitted, and this is a great defect in a book which aims at so comprehensive a survey of the subject. Operative methods and the use of bone grafts are described much less fully than the traction appliances.

The second volume opens with a very notable article on fractures of the skull. This deals in great detail with the cerebral complications of head injuries. The physiology, etiology, and pathology of cerebral disturbances are described very well, and illustrated by excellent photographs, diagrams, and coloured plates. In this, as in other sections, practical details of treatment are not discussed at a length proportionate to that devoted to the more theoretical aspects of the subject. For example, we look in vain for any light on those types of fractured base which will be benefited by decompression, also there is no mention of traumatic defects in the skull or how they should be treated. The chapter on fractures of the jaw is well illustrated and practical. The figures showing methods of bone-grafting from the crest of the ilium to the jaw are particularly useful. Fractures of the spine and concomitant injuries of the spinal cord are discussed in the same way as are those of the skull. The coloured diagrams of nerve distribution are very useful, and the pathological preparations illustrating different forms of fracture and deformity are the most perfect we have ever seen.

The remainder of the work is concerned with individual fractures of the pelvis and long bones, and bears the same characteristics as those sections which have already been noticed, i.e., a great wealth of anatomical, pathological, and clinical illustrations, but a comparative paucity of description of modern methods of treatment, particularly in regard to the use of bone-plates, nails, or grafts. A list of references to the literature concludes the book. This appears to be lengthy and complete as regards German papers, but is quite inadequate in respect of French, American, and English work.

Practical Anatomy By R. J. A. BERRY, M.D., F.R.S.E., F.R.C.S.E. Second edition. 8vo. With numerous plates (Vol. I, Superior and Inferior Extremities, pp. vi + 472, 22s. 6d. net; Vol. II, Thorax and Abdomen, pp. x + 430, 22s. 6d. net; Vol. III, pt. 1, Head and Neck and Organs of Special Sense, pp. viii + 350, 20s. net; Vol. III, pt. 2, Central Nervous System, pp. viii + 256, 17s. 6d. net.) 1922. London: H. K. Lewis & Co. Ltd.

THE second edition of Professor Berry's *Practical Anatomy* will be very welcome. It is now published in four parts, and is illustrated to a large extent by reproductions of the well-known plates of Ellis and Ford. Unfortunately the plates are reproduced without colour, and this is a very decided drawback.

The section which will be received best is undoubtedly that dealing with the "Anatomy of the Central Nervous System." The author claims, and justly, that the treatment of the subject differs materially from that given previously in anatomical manuals. The study of the gross anatomy of the central nervous system is combined with the study of its minute anatomy, its morphology, its functional importance, and its clinical applications. The author is to be congratulated very heartily on the large measure of success which has attended his efforts in combining so many aspects of the subject in one comparatively small volume. He has made the study of the central nervous system a very fascinating one, and has greatly increased its educational value to the medical student. His complete break with established tradition—so far as anatomical manuals are concerned—is an indication of the type of changes which are gradually being brought about in anatomical teaching.

The other volumes do not differ materially from the first edition. Some attempt has been made to omit minutæ, and clinical applications of anatomy have been included, rather for the benefit of the graduate than of the medical student. The B.N.A. terminology is used throughout, except in the part dealing with the central nervous system, but the replacement of the common descriptive terms by those of a biological character is cumbersome, and is certain to be received, at any rate for some time to come with disfavour in this country. It is difficult in certain parts of the body for the author to be consistent, and the term 'dorsal' is used with a double significance with reference to the calcanei. On the whole one can hardly agree with the author that "neither the older generation nor the younger will experience any real difficulties with this thorny question of anatomical nomenclature". In this country anatomical nomenclature is still unsettled, and some general agreement, preferably amongst the English-speaking peoples, or at any rate in Great Britain, will be welcomed by teacher and student alike. As matters stand at present, the medical student cannot help but acquire a totally erroneous impression of the relative importance of anatomical terms and anatomical facts.

Traité Pratique de Cystoscopie et de Cathétérisme Urétéral By G. MARION, Professeur agrégé à la Faculté, Chirurgien de l'Hôpital Lariboisière (Service Civile), and M. HIERZ-BOYER, Professeur agrégé de Chirurgie des Voies Urinaires à la Faculté, Chirurgien de l'Hôpital St Louis. Second edition, entirely remodelled. Large 8vo. Pp 480, with 60 plates in black and white and colour. 1923. Paris. Masson et Cie. 100 fr. net.

THIS handsome volume, which first appeared in 1914, has been largely re-written and extended in the second edition.

There are four parts: (1) Cystoscopic examination, (2) Ureteral catheterization, (3) Cystoscopic treatment, (4) Cystophotography. The opening chapter deals with the instruments, and gives a short description of the optical system of the indirect cystoscope. The optical system which gives an inverted image has been used for most of the illustrations, and there is some discussion as to the comparative merits of the upright and the inverted images, which appears unnecessary, having regard to the complete disappearance for many years of the inverted image cystoscope. The preparation of the instrument and the patient and the technique of cystoscopy are described.

The body of the work is occupied by a description of the cystoscopic appearances seen in diseases of the bladder and kidneys. Of these, the chapters on cystitis and growths are the most detailed. The discussion of the cystoscopic diagnosis between simple and malignant tumours is not particularly helpful, and, with the wide experience of the writers, might well be extended. Less common diseases such as bilharzia, purpura, malakoplakia, and syphilis receive very short notice. The authors very properly sound a note of warning against the danger of cystoscopy in enlarged prostate. There is a short note on retrograde cystoscopy and on urethro-cystoscopy and stereocystoscopy. The uses, limited in the authors' view, of the direct-vision cystoscope of the Luys type are described, and the application of this instrument in minor surgical interference in bladder disease is discussed.

Pyelography is described under catheterization of the ureters. The estimation of the renal function is discussed in a long and somewhat involved chapter. The urea concentration test is not mentioned, and the references to the work on this subject are entirely confined to the French literature. Lavage of the renal pelvis receives full discussion, and the authors favour solutions of nitrate of silver as the antiseptic for use. There is a good description of the treatment of bladder growths by the high frequency current.

This is a very complete and useful book on cystoscopy and its varied applications. The illustrations are numerous, and those in colour are beautifully reproduced and realistic in effect. It will be of high value to the beginner, and also to those more experienced in the study of urinary surgery.

The Treatment of Fractures with Notes upon a few Common Dislocations By CHARLES LOCKE SCUDDER, M.D., Consulting Surgeon to the Massachusetts General Hospital Ninth edition, revised Royal 8vo Pp 749, with 1252 illustrations 1923 Philadelphia and London W B Saunders Co 42s net

THIS book, which first appeared in 1900 and is now in its ninth edition, has evidently won deserved popularity in America. The present edition is an advance over its predecessor in that it includes many of the methods used or elaborated during the war, such as the Carrel-Dakin method of disinfection, transport and first dressings, and the use of the Thomas splint.

Proper stress is laid upon the principle of traction and suspension as the chief methods of treatment in recent fractures. Operative methods have been relegated so much to the background as to be almost out of sight. Otherwise all details necessary for treatment by splints are described carefully and with a great wealth of illustration.

Frakturen und Luxationen Ein Leitfaden für den Studenten und den praktischen Arzt By PROFESSOR DR GIORG MACVET, Oberarzt der Chirurgischen Universitätsklinik, Jena Royal 8vo Pp 87, with 45 illustrations 1923 Berlin Julius Springer 3s 4d

THIS brief summary of the principles of fractures is intended as a guide for students. It is good and clear as an exposition of general principles, especially as regards treatment of fractures by Bardenheuer's traction methods, but it is too short in description of individual fractures and special methods of treatment to be of much value in these subjects.

Précis de Technique Opératoire Chirurgie du Membre Inférieur By GORCES LABLAUD and JACQUES LEVEUR Fifth edition Pp 248, with 280 illustrations 1923 Paris Masson et Cie 10 fr

THIS is an exceedingly neat little summary of operative surgery of the lower extremity, with illustrations which are ideal in cleanness and finish. Osteotomy, operations on fractures, resections, arthroplasties, and orthopædic operations on the foot are treated well. The section on the operative treatment of fractures is almost limited to a description of French methods, those of Lambotte and Delbet having chief prominence. In transfexion of the lower end of the femur the transfexion pin is placed too near the knee-joint for safety. Parham's bands are represented as surrounding the conical lower end of the femur, where a flat band will not lie snugly. Operations on the neck of the femur and for exposure of the knee-joint are much too elaborate for a book of this type, whereas some simple methods are omitted. For example, transverse division of the patella and dove tailing joining are described, whilst the vertical splitting method is omitted. One figure represents a drainage tube being taken right through the knee-joint in the way which ought to be avoided.

Apart from details of this kind, however, the book is a model of precise description and apt illustration. It does not include the subject of amputations.

THE BRITISH JOURNAL OF SURGERY

VOL XI

OCTOBER, 1923

No 12

EPONYMS

By Sir D'ARCY POWER, KBE LONDON

X POTT'S PUFFY TUMOUR.

THE Observations on the Nature and Consequences of those Injuries to which the Head is liable from external Violence was published in 1760 and immediately placed Pott in the first rank of contemporary surgeons. The essay is original, well written, shows an extensive knowledge of surgical literature, and is full of case-histories which are a perfect joy to read, for they tell of the rough and tumble life in London during the first half of the eighteenth century. When it was published Pott was forty-six years old and had been surgeon to St Bartholomew's Hospital for eleven years. Four years previously he had been confined to his bed for a considerable period with a broken leg, and this essay is doubtless one of the means he took to relieve the monotony of his convalescence. Indeed, his biographer states that "the appearance of Mr Pott as an author was an immediate effect of this accident. It was then not an early period of his life and it is possible, that the busy scene in which he had been engaged might have occupied his mind much longer, and that without some powerful check to the train of his pursuits he might never have discovered in himself those superior powers of scientific disquisition, that correct taste and masterly command of language, which have placed him in the first rank of medical writers. Engaged from early youth in the constant transaction of business, he probably till this period had indulged but little in the pleasures of speculative investigation, but was never afterwards long unemployed in some literary work."

The alliteration of 'Pott's puffy tumour' seems to have taken a firm hold of the surgical mind although the condition is of no great importance and is now rarely seen. The passages describing it are contained in the second section of the *Observations* which deals with the effects of contusion on the dura mater and parts within the skull. After discussing whether the cerebral symptoms due to intracranial hæmorrhage can be distinguished from those due to suppuration, he says "If there be neither fissure nor fracture of the skull, nor extravasation, nor commotion underneath it, and the scalp be

neither considerably bruised, nor wounded, the mischief is seldom discovered, or attended to for some few days. The first attack is, generally, by pain in the part which received the blow. This pain, though beginning in that point, is soon extended all over the head, and is attended with a languor, or dejection of strength and spirits, which are soon followed by a nausea, and inclination to vomit, a vertigo or giddiness, a quick and hard pulse and an incapacity of sleeping, at least quietly. A day or two after this attack, if no means preventative of inflammation are used, the part stricken generally swells, and becomes puffy and tender, but not painful, neither does the tumour rise to any considerable height, or spread to any great extent. If this tumid part of the scalp be now divided, the pericranium will be found of a darkish hue and either quite detached or very easily separable from the skull, between which and it, will be found a small quantity of a dark-coloured ichor."

The sign is referred to a little later on in the argument, when he says "If the symptoms of pressure, such as stupidity, loss of sense voluntary motion, etc., appear some few days after the head has suffered injury from external mischief they do most probably imply an effusion of a fluid somewhere, this effusion may be in the substance of the brain in its ventricles, between its membranes, or on the surface of the dura mater, and which of these is the real situation of such extravasation is a matter of great uncertainty, none of them being attended with any peculiar mark, or sign that can be depended upon, as pointing it out precisely, but the inflammation of the dura mater, and the formation of matter between it and the skull, in consequence of contusion is generally indicated and preceded by one which I have hardly ever known to fail, I mean a puffy, circumscribed, indolent tumour of the scalp, and a spontaneous separation of the pericranium, from the skull under such tumour. These appearances therefore following a smart blow on the head, and attended with languor, pain, restlessness, watching, quick pulse, head-ache, and slight irregular shiverings, do almost infallibly indicate an inflamed dura mater, and pus, either forming or formed between it and the cranium."

The causes of the smart blow on the head are given in the illustrative cases appended to the essay. "A poor fellow crossing Tower-hill, got, before he was aware of it, into a mob, that was endeavouring to rescue a sailor from a press-gang. The man was knocked down. When the crowd dispersed he was found senseless, and in that state was brought to St Bartholomew's hospital, where he was immediately let blood and put to bed. At the end of three days the man found himself so well, as to leave the hospital, and go to work. On the twelfth day from that of the accident, he came to my surgery, and complained of being much out of order. He looked ill, assured me he had lived very soberly from the time of his leaving the hospital. I took him into the house again, bled him, ordered him a glyster immediately, and that he should be kept in bed. On the 15th day after the accident the tumour of the scalp was more apparent, but yet seemed to contain little or no fluid, and was about the breadth of a crown piece. I would have removed that portion of scalp but while I was intending it, the poor man had a very severe rigour, which disordered him so much, that he begged to be let alone for the

present The next morning the tumour was more risen contained palpably a fluid but was by no means tense, I took away the whole tumid piece by a circular incision That whole night and next day he was delirious his skin burning hot, he had frequent spasms which shook his whole frame and that night (the 17th from the injury) he died

Another case was that of "a young fellow of about twenty years who was thrown from an unruly horse against one of the rails in Smithfield The blow was great, he lay senseless for above an hour, and in that state was brought into St Bartholomew's hospital"

"A man in the neighbourhood of St Giles's had a quarrel with his wife in which he struck her over the head with a mop-stick The blow was a smart one, but as it neither fetched blood nor brought her to the ground it only finished the dispute and no farther notice was taken of it The woman followed her business, which was that of crying greens about the streets and lived (to use her own words) sometimes drunk, sometimes sober for a week On the eighth day from that of the blow she found herself so ill, that she applied to the hospital for admission, and was taken in as a physician's patient for a fever The doctor wrote for her, and the day after this (the tenth day from the accident) the sister of the ward, in cutting off the patient's hair which was full of vermin discovered a swelling, which she desired me to look at, it was flattish, about the breadth of the palm of a hand, and lay immediately a-cross the sagittal suture I opened the tumour, and finding the bone bare, cleared away the scalp largely and circularly I then applied a trephine on one side of the suture and close to it, and found the dura mater altered in its natural colour, and as it were smeared over with matter She had an attack of erysipelas, was trephined twice more and died on the sixteenth day

"A Lunatic threw himself from a window, two stories high, and in his fall, struck his head first again a sign-post and then against a slated pent-house He was taken up senseless and remained stupid above twelve hours, but being in that space of time let blood freely twice, he recovered his senses, but showed no signs of a right understanding He passed two days and nights in the utmost disorder and disturbance He was confined in a strait waistcoat and kept two people constantly employed in holding him, at last by repeated phlebotomy, and taking a large quantity of opium, he fell asleep slept near twelve hours, and then awoke perfectly tranquil and perfectly rational He would have been permitted by his friends to have gone out a little way into the country, but lest there should be any latent mischief, I advised him to keep quiet a little longer, and to live with great caution, which advice was followed On the tenth day from that of the accident, he lost his appetite looked dull and languid, refused food and company, complained that his head ached and said, that he had not slept So little time had passed since he had been disordered in his mind that, from his aspect and manner I suspected a return of his lunacy I let him blood again, directed that he might be kept low and desired his brother, who was an apothecary, to give him an opiate at going to bed" In spite of this treatment he got worse part of his scalp was removed, he was trephined three times, an abscess was evacuated, and he recovered.

"A Watchman whose stand was in Whitechapel, got into a scuffle with some drunken sailors and received several wounds and blows on his head, from some of which he lost so much blood that he was the next day brought into St Bartholomew's hospital in a very weak low state. As he had already sustained great loss of blood and was more than sixty years old I made use of no further evacuation, but dressed his head superficially, and directed that he should be kept in bed. At the end of about a week, the general tumefaction of the head was nearly gone, and all the wounds in a healing state, the man transgressed rules of the hospital by staying out all night and was discharged. On the fifteenth day from that of the accident he came to me again complaining of headache, giddiness, sickness, failure of strength, loss of appetite, and want of sleep. I took him into the house again, removed a circular portion of the scalp including the wound, found bare bone, perforated it in the middle and found a small quantity of matter on the surface of the dura mater. Another perforation was made on the eighteenth day and a third on the twentieth. This procured so large a discharge of pus, that I was very apprehensive that the extent of the mischief was too great for the assistance of art to prove effectual in, however, I was luckily disappointed for in a very few days more all his bad symptoms gradually left him, and the man got perfectly well."

"A Drayman drunk, and sleeping, fell from his dray, and his head was so squeezed between the wheel and a post that a considerable portion of the scalp, together with the pericranium was forced from off each parietal bone. He was brought to the hospital senseless. He was largely let blood, the separated scalp was removed and the bone dressed with dry lint. The next day the man was so well and so perfectly master of what sense he had, that I was inclined to believe that a great deal of the last night's appearance was owing principally to liquor. On the thirteenth day he was so well, that having a large family to work for, he desired to be discharged from the hospital, and to be made an out-patient, but I had so often been deceived by the fallacious appearance of such cases that I persuaded him to stay another week. Cerebral symptoms appeared on the sixteenth day and on the seventeenth he was so ill that I vain would have set on a trephine, but the man would not permit me. On the twenty-third day from that of the accident he died, having been paralytic in his leg and arm from the twenty-first."

"On the tenth of February 1765, John Biggs, a lad about thirteen years old was driving a horse round in a grinding mill, the horse not being used to the work, ran round very fast, the boy fell and received such a blow from some part of the frame in which the horse worked, that he lay deprived of sense, for some time, that is, until somebody came in to enquire, why the mill went so rapid. In a few hours, by the assistance of phlebotomy, he seemed to be very well again. His wound was dressed by the family apothecary for a week during which time he did not seem to have any other complaint, except now and then having a slight headache. The wound not healing kindly, the boy being a country boy, hired only for the purpose of driving the mill-horse, and the people with whom he lived being tired of keeping him unemployed, he was brought to the hospital. On the eighth of March he was seized with a fever, beginning with a kind of cold fit. On the tenth he was

much disordered, complained of acute pain in his head, and his wound, which had been healed, broke out again, the pericranium separating from the bone on the twelfth, he became senseless to all outward objects, was convulsed in all his limbs, and jaw-locked. On this day Mr Crane trepanned him, in the upper fore and right side of the frontal bone. On the surface of the dura mater was found a considerable quantity of good matter. On the next morning he died.

There are some further case-histories. One of "a young man playing at cudgels in Moorfields who received a stroke on his forehead." Another of "a Gentleman's coachman who was thrown from his box on the road between London and Richmond and received a wound in his forehead. The next day his master, who was governor of St Bartholomew's and a timorous man sent the patient into that house." Another of a man who received a severe blow on his head "in that ever memorable defence made by Capt. Gilechrist, on board (as I think) the Southampton man of war, against a most shameful superiority of French force. He was treated at the hospital in Gosport and three weeks later was sent to St Bartholomew's Hospital and put under the care of Dr. William Pittcairn." A boy belonging to a horse-dealer in Smithfield was thrown from a horse with great violence against one of the sheep-pens. Two female inhabitants of St Giles' got drunk together and quarrelled, one of them threw a stool at the other and knocked her down. The edge of the stool cut through the scalp and broke the left parietal bone. The girl was dressed that night by somebody in the neighbourhood and she was brought the next morning to the Hospital. On the eighteenth day a tumour appeared on the other side of the head. A trephine was set on but on the twenty-third day she died. "A boy about eight years old, the son of a Jew merchant in the city received a blow on his head with a stick from his tutor. The stroke made him giddy for a few minutes but as no blood was shed and the pain soon ceased he concealed it till it was discovered by his barber that his head was swollen in that part. Mr Serjeant Amyand and Mr Shipton were joined with me in the case. We found that the sagittal suture was broken, and that a portion of the fracture was forced into the sinus. After much deliberation and conversation about the hazard of wounding a sinus (which was indeed already wounded by the broken bone) it was agreed to set a trephine on the suture in such a manner that the whole surface should be comprehended within its circle. This was done, and the patient is alive at the time of my writing this." "A girl about fourteen was knocked down by her mother with an iron poker of considerable weight, the latter immediately ran away and the former was brought senseless to the hospital." She died on the seventeenth day. "A girl about fifteen years old, crossing Smithfield on a market-day, was tossed by an ox, and fell with her head on the flat stones within the posts. As her dress was mean, and nobody knew anything of her, she was brought senseless into the hospital. She died on the twentieth day from that of the accident having been terribly shaken by spasms for several hours." "A boy about fourteen years old following a led horse, was desired by the servant, in whose hand the horse was, to strike him, the boy did so, and received a blow from one of the horse's heels, which brought him to the ground senseless. On the twenty-second day he became delirious and

convulsed and on the twenty-third died" "A woman came to my house complaining that her husband had kicked her down stairs and had broke her skull I took her into the hospital, where she was taken all possible care of, but she became first paralytic, and then comatose and so died"

It is somewhat remarkable that Pott was able to obtain a post-mortem examination of the heads in each of the fatal cases, whilst the time that he must have devoted to the preparation of the essay is shown by the fact that he had read, and quotes, Hippocrates, Celsus, Aëthigenes, Galen, Oribasius, Paulus Ægineta, Rhazes, Theodoric, Brunus Lanfrank Gui de Chauliac, Petrus Angelatus, Berengarius of Carpi, Fallopius, Paww Fabienus Hildanus, Andreas Croce, Peter of Marchetti, Ambroise Pare, Muys and Wiseman, Le Dran and Moigagni It is clear that Pott read Latin and French with tolerable ease, for he quotes the originals Greek authors he always quotes in their Latin dress, so he was probably not equally versed in Greek

PRIMARY CARCINOMA OF THE LUNG.

A DISCUSSION OF ITS INCIDENCE AND DIAGNOSIS

BY KENNETH PLAYFAIR AND CECIL P. G. WAKELEY, LONDON

INTRODUCTION

Since the original paper by Bayle over a century ago in which he described a case of primary carcinoma of the lung, many further cases have been recorded. Adler published a treatise in 1912 on *Primary Malignant Growths of the Lungs and Bronchi* in which he records 374 cases of primary carcinoma of the lungs and bronchi collected from literature up to that date. Following Adler's admirable monograph many further contributions have been made to literature on this subject. It is of significance that during the decade ending in 1922 the three years 1920-22 yield a greater number of recorded cases than do the previous seven years. While the last three years occur immediately after the late war—during which perhaps medical research was directed to the immediate requirements for the benefit of the armies both in the field and in training—yet they are also the three years following on the great pandemic of influenza, which was notable for its ravages on the respiratory system. The etiology of carcinoma of the lung remains as obscure as does that of carcinoma elsewhere, but the apparently increased frequency of the disease arising in this situation since the influenza pandemic of 1918-19 is regarded as significant by most recent writers. Several recent American writers, Moise in 1921 and Barion in 1922 among others, lay particular emphasis on this fact.

The symptomatology and diagnosis have been discussed at length by many. While this rare disease may in its classical form present no great difficulty in diagnosis, yet from the similarity of its symptoms and signs to those found in other more common pulmonary diseases it still offers many difficulties. Records of cases reported in the past decade yield abundant evidence that often either no diagnosis, or an incorrect one, has been made prior to autopsy.

A correct prognosis is impossible while there exists any confusion with tuberculosis. Treatment in any case of doubtful value in this disease, differs entirely from that in pulmonary tuberculosis. That primary carcinomata of the lung are undoubtedly very rare is evidenced by the few cases recorded in comparison with the common occurrence of carcinomata elsewhere in the body. Yet doubtless many cases undiagnosed in life pass unrecorded from the lack of autopsy. Many cases of pulmonary tuberculosis fail to come to autopsy and not infrequently cases of pulmonary carcinomata are complicated by this disease. In such circumstances a diagnosis of phthisis

is probably made, being comparatively obvious, as well as being adequate both for purposes of registration and for the satisfaction of the patient's relations

From the fact that we have been able to find only three cases reported in this country since 1918, while in America more than thirty were recorded by McMahon, Carman, Barron, and others, it might be inferred that this disease was of less common occurrence in this country than in the United States. Yet we are inclined to think that the number of cases in this country would be increased were infirmity statistics investigated. The more chronic cases would be likely to find their way to these institutions, under the economic stress of hospital accommodation here. Again, the lack of routine autopsy in this country may help to account for the apparent difference in frequency in the two countries.

In a thorough search of the clinical and pathological records of King's College Hospital from 1901 to the present date, we were only able to find four clearly established cases in 3183 post-mortem examinations and a further two in which the clinical diagnosis could not be subsequently confirmed by autopsy, the latter we do not record. This represents only 0.1 per cent of primary carcinomata of the lung at autopsy in the experience of a London teaching hospital extending over 22 years. We were able to investigate every possible case carefully, and have conducted further microscopical examinations in all the doubtful ones. The four reported in this paper are only the cases in which there is no element of doubt in the diagnosis.

ETIOLOGY

Etiological factors of primary importance, such as tuberculosis and pneumoconiosis, do not appear to have been present in our four cases. Chronic bronchitis had been present in *Case 3*. It was also present in *Case 1*, associated with asthma of eight years' standing. In *Case 2*, bronchial trouble arose from influenza nine months before the patient came under observation. *Cases 1* and *3* both denied having ever had influenza in recent years, while *Case 4* had had influenza three times severely during three successive years about 25 years previously but apparently there were no subsequent bronchial symptoms. Several American writers lay emphasis on influenza as an etiological factor of immediate importance. Is it not more probable that chronic inflammatory changes in the bronchial mucous membrane provide the antecedent factor, influenza being merely one of many conditions which can result in chronic bronchitis?

It would be of interest to know whether any cases of chronic bronchitis arising after 'gassing' ever develop primary pulmonary neoplasms. We have been unable to discover any record of such an event.

PATHOLOGY

Ewing states that there are three types of pulmonary carcinomata histologically distinguishable, according as to whether they arise in (a) bronchial epithelium, (b) bronchial mucous glands, or (c) alveolar epithelium. However, there may remain considerable difficulty in the identification of some

cases, this difficulty being directly proportional to the duration and extent of the growth

In the four cases here reported there is trouble in classification in only one—namely, *Case 3*. They are all columnar-cell carcinomata, but in *Case 1* (*Fig 141*) cilia may be observed, and we have therefore considered that it has arisen from the bronchial epithelium. *Case 2* (*Fig 145*) and *Case 4* present histological features very similar to one another.

DIAGNOSIS

A diagnosis of primary carcinoma of the lung cannot be made without suspecting it. In such a disorder—which from the number of fully recorded cases may no longer be regarded as very rare, yet in comparison with the extremely frequent occurrence of pulmonary tuberculosis may justly be regarded as being comparatively so—the main difficulty lies in the failure to suspect the presence of malignant disease in this situation. Only brief descriptions are as yet to be found in the leading text-books, and—while noted by the reader—are rapidly forgotten. Cramer and Saloz published two papers on the subject. In the first they report 29 cases collected in Geneva during twenty years, in which 80 per cent of cases were not correctly diagnosed before autopsy. Later, in their second paper, they report a further series of 8 cases, with only 25 per cent failure in clinical diagnosis. It would appear that this remarkable improvement in accuracy of diagnosis is due to the fact that primary carcinoma of the lung was, by them, well recognized as a consideration in the differential diagnosis.

Some difficulty in breathing is probably the earliest symptom to arise, and this may be accompanied by a cough, frequently of an unproductive nature. Later, when the growth has involved the pleura, pain, either dull and aching or sharp and stabbing in character, is extremely constant.

Much has been written on the sputum. The 'characteristic' black-currant jelly or prune-juice sputum is of rare occurrence, and even then is only found in the later stages, but hæmorrhage may not infrequently be present. The absence of tubercle bacilli on repeated examination is suggestive, and calls for a careful revision of the diagnosis. Degenerate carcinoma cells with many fatty granules are very conclusive when present. It should not be forgotten, however, that the characters of the sputum will depend on the actual pulmonary condition present. Bronchiectatic, tuberculous, or pneumonic sputa quite typical in character may not infrequently be found, and from that an erroneous diagnosis is made.

The signs present in the earlier stages are usually negative, but later there is impaired mobility of the affected chest, flattening, dullness, diminution of vocal vibrations and an entry—all characteristic of collapse of the lung consequent on the bronchial obstruction, and not of the tumour mass itself. Both ulceration of the tumour with cavity formation, and bronchiectasis may occur, with typical signs, leading to confusion in the diagnosis.

X rays are by some claimed to be absolutely diagnostic. This may be so in a few cases, but from the very nature of the local effects of the tumour the appearances must be not only extremely variable, but not distinctive.

The X-ray appearance of the lung depends on the variations in density of the lung substance. Extensive fibrosis both of lung and pleura, and the occurrence of adherent pleura or pleural effusion, must mask the picture. This may be seen in the skiagram taken in *Case 1* (*Fig 139*), in which with the onset of symptoms a well-marked pleural effusion masked all underlying phenomena and the translucent area at the apex corresponded with the sole remaining portion of lung which was found on clinical examination to be functioning. An almost identical appearance was found in the skiagrams taken in *Case 4*. We would emphasize the fact that while, together with symptoms and clinical signs, X rays prove an extremely useful adjunct to diagnosis, too much reliance must not be placed on skiagrams, to the exclusion of a careful clinical examination.

Bronchoscopy has been performed, it can only be of value when the tumour originates in one of the main bronchi. Lung puncture, at all times an extremely dangerous measure, has been advocated, but the dangers of hæmorrhage and infection of the pleural cavity outweigh the possible value of obtaining a little carcinomatous debris in the material withdrawn.

Since an early diagnosis is imperative prior to any radical treatment being undertaken, the important early symptomatology in primary pulmonary carcinoma is here recapitulated. Some difficulty in breathing, often paroxysmal in type and frequently described as 'asthma', arising in later life, must be regarded with grave suspicion. Cough may be very early, and is frequently troublesome, irritating, and unproductive. The latter we regard as very significant when no local pharyngeal cause is present. Expectoration may be present, but in the earliest stages is rare. The absence of tubercle bacilli on repeated examination is suggestive, while degenerate carcinoma cells, when found, render the diagnosis certain. Hæmoptysis in its various types is unusual till the disease is well advanced, and is then only rarely distinctive. Pain, a very constant symptom, would appear to indicate pleural involvement, and cannot be included in the early symptomatology. The physical signs, which we would emphasize, are dependent on the resultant failure in the inflation of the lung from bronchial obstruction, they are slight flattening, with impaired mobility on respiration, of one side of the chest, with deficient air-entry and impaired note on percussion, and are usually unaccompanied by any evidence of localized consolidation.

TREATMENT

Surgical—Very few cases of primary carcinoma of the lung can be treated surgically. Seydell in 1910 stated that he was not at all certain that pulmonary carcinoma could be operated upon with a good result. This is comprehensible because 90 per cent of primary carcinomata start near the root of the lung and metastasize early. However, Lenhartz was successful in one case out of five. The case was a diffusely infiltrating carcinoma, and almost the whole lung was excised bit by bit. The wound was left open, and systematic X-ray treatment was given until the wound had finally healed. The patient died two and a half years after the operation. Morrison Davies, in his excellent book, *The Surgery of the Lung and Pleura*, reports a successful case of resection of a lobe of the lung for primary carcinoma.

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Before the war many devices and many elaborate types of apparatus were brought forward by different surgeons for reducing the pressure outside the thorax of the patient so that the lung might be kept distended during the operation. Fell, O'Dwyer, Matas, Sauehnech and Willy Meyer have all invented different kinds of cabinets but these are clumsy, take up a large amount of room, and are expensive to run. Intratracheal ether insufflation has quite superseded every other method of apparatus which compensates pneumothorax.

It is advisable to give the patient a hypodermic injection of morphia (gr. $\frac{1}{6}$) and atropine (gr. $\frac{1}{100}$) half an hour before the operation.

The fifth rib is excised subperiosteally throughout nearly its whole extent, some surgeons, including Morrison Davies, have not found it necessary to resect a rib, but make an incision through the fifth intercostal space and rely on very strong mechanical retractors to ensure sufficient exposure of the lung. Adhesions between the parietal and visceral layers of the pleura are now divided, and the vagus nerve is injected with novocain in order to abolish post-operative shock. Davies found, as a result of experimental investigation on animals, that the intrathoracic anaesthetization of the vagus completely abolishes the shock of manipulations on the lung.

The affected lobe of the lung is now exposed, and its vessels are defined by blunt dissection and divided between double ligatures. The lung tissue at the base of the lobe is carefully incised, and all bleeding points are immediately ligatured. Especial care is required in dealing with the bronchus, which should be the last structure to be severed. A purse-string suture is passed if possible round the outer coats of this structure and the bronchus is crushed by a powerful clamp. The actual cautery is finally used to sever the crushed portion of the bronchus. The proximal end of the crushed bronchus is invaginated and the purse-string suture tied. If possible any raw lung tissue is drawn over the stump of the bronchus. A small drainage tube is inserted for forty-eight hours. If, as frequently happens, an effusion takes place, it should be aspirated with oxygen replacement.

Radiological—In the almost inevitably fatal course of the disease under the usual methods at our disposal, it would seem that radiation therapy would offer the best chance of arresting a growth of the lung or possibly reducing it to operative proportions. In view of the extremely rare condition, statistics of such methods of treatment are necessarily difficult to obtain. If deep therapy treatment is applied, it is essential that the thoracic region should be mapped out into a series of areas to which the radiations are to be directed. Indications for the necessity of specially pushing treatment in one or more particular areas will be afforded by examinations of skiagrams taken from time to time. In 1922 Rolland, of Paris, treated a case of carcinoma of the hilum of the lung by deep radiation. This treatment caused the primary lung condition to improve considerably, but the man died from a metastasis in the cerebellum.

PROGNOSIS AND COMPLICATIONS

By the time the clinical and other evidence justifies a diagnosis of primary pulmonary neoplasm the disease is far advanced and but a few months of life remain. The duration, however, may be very variable—that is to say,

the duration from the first onset of symptoms to the inevitable termination of life. In our series, *Case 1* strongly suggests an eight-years' history—that is, with the onset of 'asthma' as the first symptom. On the other hand, *Case 2* presented no symptoms prior to nine months before death, while in *Cases 3* and *4* there is only three months' history from first to last.

Complications both varied and numerous may arise to add to the discomfort of the patient and to difficulties in diagnosis. Septicæmia, hæmorrhage, pulmonary tuberculosis, bronchiectasis, pneumonia, abscess of the lung, pleurisy, pleural effusion, and empyema are the more common local complications, while the local spread of the growth into the mediastinum, or the invasion of glands in that area, may give rise to many different effects of pressure on any or several of the vessels, nerves, etc., traversing this area.

Metastases from carcinoma of the lungs have been found in all structures of the body and nothing distinctive appears to be associated with the different histological types.

CONCLUSIONS

1 Primary carcinoma of the lung, while still correctly regarded as a rare condition, is probably of more frequent occurrence than is usually admitted. Cases reported from America during the past five years are very much more numerous than in this country. This may be a true indication of its relative incidence in the two countries, but it is to be doubted if it is so. Absence of routine autopsy here, and perhaps a reluctance to record such cases, may account for the apparent difference.

2 The etiology is little understood, but the fact that chronic inflammatory affections precede this type of carcinoma may be a factor of importance, as is frequently the case in carcinoma elsewhere. Chronic bronchitis originating from respiratory lesions of influenza may be one of the most important precursors of pulmonary carcinoma.

The pathology is still obscure. Although many cases are readily classified histologically, many others, especially advanced cases, must remain unidentified as regards their exact origin.

3 We would emphasize the need of a constant consideration of primary pulmonary neoplasm in all cases presenting any chronic lung symptoms, such as shortness of breath, cough, hæmoptysis, and thoracic pain. It is upon an early and correct diagnosis that the future of surgery and radiotherapy in treatment must depend.

Diagnosis must primarily depend on a detailed and correct correlation of the history and clinical observations, while radiography, a useful adjunct at times, is too often unreliable. Degenerate carcinoma cells when present in the sputum are diagnostic but this is a rare occurrence, and may be overlooked during the routine examination for tubercle bacilli.

4 Surgery, with intratracheal anaesthesia, and possibly the simultaneous administration of radiotherapy, offer the only means of eradication of this disease, but progress must be slow until the early symptomatology is more generally recognized.

PARTICULARS OF CASES

Case 1—T H, male, age 47 was admitted on Sept 20 1921, complaining of asthma and bronchitis. He had had rheumatic fever fifteen years previously, from which time he dated his chest symptoms of frequent cold and persistent cough. Eight years ago he started attacks of asthma, four years later he attended a chest hospital for this complaint, with improvement of his symptoms, but with cessation of treatment his attacks of asthma recurred and had become worse. While generally dyspnoeic, he had severe attacks of dyspnoea, described by him as 'asthma' which followed any exertion either during the day or at night. They lasted from ten to fifteen minutes, leaving him very exhausted, and were accompanied by a sharp pain in the left chest and shoulder. There was no history of tuberculosis or venereal disease.

On examination, the temperature ranged between 97° and 101°, and was remittent in type. Respirations were 20 to 24, and pulse about 92. The right side of the chest moved well, but the left side was flat, and did not appear to move on inspiration. Fremitus was absent, and there was dullness on percussion over the whole of the left lung except at the apex in front above the clavicle where there was a small area of resonance. On auscultation of the left lung no breath-sounds were audible except over the small area of resonance at the apex, where they were distant and feeble, but vesicular in type. No adventitious sounds were present. The physical signs of the right lung were hyper-resonance all over, well-marked vocal fremitus and the prolongation of audible expiration, together with numerous and varying rhonchi, suggested a diagnosis of emphysema with chronic bronchitis of this lung. There was a slight scoliosis of the dorsal vertebrae, with its convexity towards the right side. The cardiac apex was felt in the 5th space in the nipple line, but could not be defined by percussion. The right border was half an inch to the right of the sternum. There was therefore no cardiac displacement. The heart-sounds were normal. The alimentary and nervous systems presented nothing abnormal. The urine was normal. The sputum, scanty in amount, was frequently examined for tubercle bacilli without any result.

The chest was explored on Oct 2, 1921, in the area of the 8th interspace in the posterior axillary line, but nothing was obtained. The signs in the chest remained the same, and X-ray examination demonstrated pleural adhesions over the left dome of the diaphragm, with the presence of a pleural effusion. On Oct 10 paracentesis thoracis was again performed in the left 3rd interspace in the mid-axillary line and greyish thick pus was found. Resection was immediately performed. On opening the pleural cavity, about 15 oz of thick pus were evacuated, which was followed by a copious hæmorrhage necessitating tight packing. Forty-eight hours later the packing was removed, and replaced by a large drainage tube, the wound being partially sewn up. The patient then rapidly improved. The temperature settled down, and the wound had completely healed by Nov 24, i.e., six weeks after operation.

The films of pus showed degenerated polymorphonuclear leucocytes and a few degenerate cocci. Cultures grew pneumococci after forty-eight hours. The signs in the lungs remained about the same. The left lung was quite dull on percussion, vocal fremitus was absent, and breath-sounds were just audible over the apex. No adventitious sounds were present in either lung. There were no symptoms at rest, and in this condition he left hospital for a convalescent home. A tentative diagnosis of pulmonary malignant disease was made.

He was re-admitted on Feb 17, 1922, two and a half months later, as the empyema wound had broken down and was discharging pus. He had been well up to the beginning of February, when he developed a 'cold', followed by an irritating cough. The lung signs were the same as on his former discharge from hospital. The temperature was 99°. A tube was inserted into the sinus and a quantity of pus liberated. He was X-rayed on Feb 25, the report being "Complete opacity of left lung except at the apex" (Fig 139). On Feb 28 a considerable quantity of dark-red viscid fluid was discharged, accompanied by a rise in temperature to 101°. The pus on examination was found to consist of blood-clot only, and no evidence of neoplasm.

was detected. At this time he complained of pain and tenderness on removal of the tube. An X-ray examination was made on March 6, the sinus being injected with Beek's paste. Report "Beek's paste seen in a sinus extending from the level of the diaphragm to root of lung." The temperature rapidly subsided, the cavity became obliterated, and finally the wound had healed before discharge on March 16.

On June 20 he was again re-admitted, complaining of pain in the back, localized to the neighbourhood of the 6th dorsal vertebra. There was dyspnoea on exertion,



FIG 139—Case 1. Skiagram taken on Feb 25 1922 showing complete opacity of the left lung except for an oval area at the apex, the small area of functioning lung which gradually became obliterated by the irregularity of the sides of the 2nd to 5th dorsal vertebrae can be seen and of the lung growth. The right lung shows some hilus fibrosis, with diaphragmatic adhesions. (Skiagram reversed)

and aggravation of pain by any movement. These fresh symptoms, arising shortly after leaving hospital had been gradually increasing during the past three months. On examination, the heart was normal and apparently not displaced, but the apex was fixed. The lung signs were the same as on the last examination—i.e., marked flattening, absence of expansion, vocal fremitus, and resonance, and complete dullness on percussion over the left lung. The right lung moved well, but was

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hyper-resonant on percussion, vocal fremitus and resonance were good and a few rhonchi could be heard, mainly in the upper lobe. X-ray examination at this time showed irregularity of outline of the bodies of the 2nd, 3rd, 4th and 5th dorsal vertebrae, but no definite destruction of bone, there was also some curvature of the spine. The right lung was clear, except for some increase of density at the hilus. The left lung was quite opaque.

On July 17, the left chest, *one inch* smaller than the right was flat, dull all over,

FIG 110—Case 1 Left lung. The growth is clearly seen involving the whole of the upper lobe with the exception of a small area of complete collapse at the apex. Growth may be seen extending down into the base of the lower lobe external to and compressing the bronchi, which are filled with a very thick brownish secretion the consistence of firm jelly. In the lower right corner is seen the densely adherent pericardium, while over the apex the pleura, more than a quarter of an inch in thickness remains to indicate the denseness of the adherent pleura.



and vocal fremitus was absent except for a small area above the 3rd rib, where it was just perceptible. Vocal resonance and breath-sounds were inaudible except over this same area. Massage and breathing exercises were given.

On Aug 4 the patient complained of slight increasing weakness of the legs. There was definite bilateral spasticity, with increase of tendon reflexes, an extensor plantar response and absent abdominals. Sensation was much impaired up to the level of the nipples, a diagnosis of compression paraplegia was made, the lesion being in the neighbourhood of the 5th dorsal vertebra. The blood and cerebrospinal

fluid gave negative Wassermann reactions Lumbar puncture yielded 20 c c of fluid clear, but faintly yellow in colour, and under slight pressure, containing 2 cells per cubic centimetre Total protein 0.45 per cent, in very large excess Globulin reaction strongly positive Carbohydrate and chlorides normal Haemoglobin nil

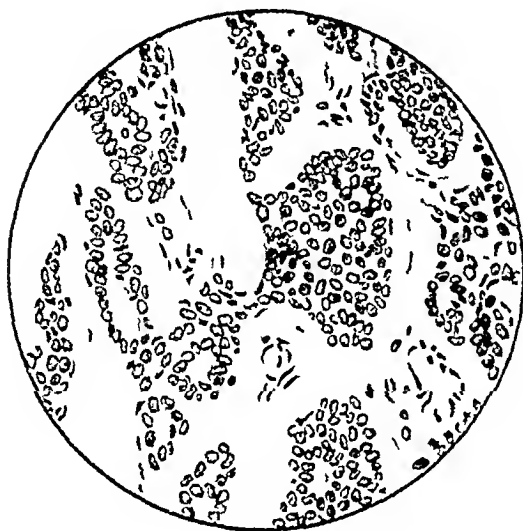
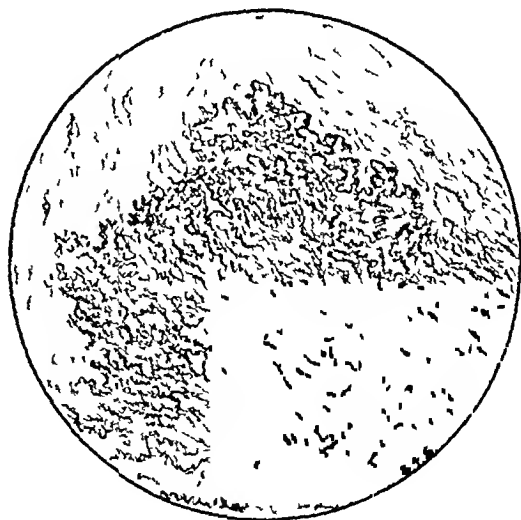


FIG 141—Case 1 Section of growth in left lung showing a columnar celled carcinoma in which most of the carcinoma cells are arranged in masses, in some cases solid, and in others surrounding one or more central spaces containing mucoid material Where the formation of tubules is well marked and these tubules are lined by epithelium only 2 or 3 cells thick, the cells can be seen to be definitely columnar in type and in some cases ciliated The stroma is composed of dense fibrous tissue with a few blood cells

Biuret reaction negative No spontaneous coagulation, and no coagulation on addition of a drop of fresh blood—i.e., From s syndrome—except for clotting

On Aug 10 a more detailed examination of the nervous signs revealed a complete paralysis of both lower limbs, with painful spasticity of both legs Pin-prick

FIG 142—Case 1 The section taken from the posterior internal margin of the left lung shows extensive fibrosis with the later stages of complete pulmonary collapse All cellular structure has completely disappeared, and only elastic fibres remain to identify the tissue In a thorough search of the rest of the lung which had not been invaded by growth no areas of a lesser degree of collapse were seen indicating the extreme degree of universal collapse and fibrosis of the diseased lung



sensation was absent below the level of the 5th rib on both sides Sensations of cold and heat, however, were present There was some incontinence of urine The condition progressed, and in view of the severity of the pain laminectomy was done to relieve pressure On removal of the posterior portions of the bony arch from the

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2nd to 6th dorsal vertebræ, fairly extensive growth was seen to surround the cord. The dura was divided vertically at the level of the 4th dorsal vertebra for about 1½ in., and two small hard masses were found on the arachnoid, which were removed for microscopical examination.

REPORT — *Mass from beneath dura mater*

Section shows a fibrous-tissue stroma. In places there are quite young fibroblasts, in others old fully-formed bundles of fibrous tissue. There is in the smaller pieces of tissue submitted what appears to be laminated blood-clot. Throughout the stroma there are scattered mononuclear cells, endothelial in type. The specimen teased out and examined wet showed a similar arrangement, but the endothelial cells were more numerous.

The membranes were distended owing to the pressure of the cerebrospinal fluid which was partially drained by incision at the 6th dorsal vertebra. No evident abnormal con-



FIG 143.—Case 1. This shows part of the bodies of the 2nd, 3rd, and 4th thoracic vertebra invaded by direct extension from the adjacent primary focus in the lung. The whole of the body of the fourth vertebra is invaded by growth, which extends upwards under the anterior common ligament on the left side.



FIG 144.—Case 1. A transverse section of the cord at the level of the 5th dorsal vertebra, showing general thickening of the dura, with—anteriorly and to the left—a portion of growth which has extended from the lung through the bodies of the vertebra (4th and 5th dorsal) into the bony canal and is exerting pressure on the cord at this level. Nowhere have carcinoma cells penetrated the dura.

dition of the fluid was noted. The wound was then sewn up, and healed rapidly. The signs of pressure on the cord were not apparently relieved.

By Nov 1 a bed-sore had been developed over the sacrum. Emaciation was now rapidly progressive, with severe pain in the left chest, which had become dull and non-resonant even at the apex. Numerous râles were heard in the right lung. The patient was now under morphia, and presented the typical appearance of advanced cachexia.

On Nov 14 he developed a large fluctuating mass over the middle of the manubrium sterni, which progressed to the extent of necrosis of the overlying skin

before death took place, on Nov 18, from toxæmia and exhaustion.

AUTOPIA.—The body was wasted. A large ulcerating swelling over the manubrium sterni was present and had resulted from an osteomyelitis of that bone, spontaneous fracture having occurred. The abscess cavity was entirely anterior to

the pericardium, which was greatly thickened. There was also a large and deep sloughing bed-sore over the sternum, from which the infection in the manubrium had probably arisen.

The heart was not abnormal. The right pleura was normal, save for some recent adhesions along the mesial border anteriorly. The left pleura was enormously thickened and adherent all over, with dense fibrous tissue. The right lung showed a slight degree of fibrosis, with a recent generalized bronchitis. The left lung showed an extreme degree of fibrosis, with complete collapse of the lower lobe (Figs 140, 141, 142). The bronchi were greatly thickened, and at the hilus of the lung the main bronchi were infiltrated with growth and full of a thick brownish jelly-like material. The upper lobe was replaced by a firm, tough growth, apparently arising primarily in that situation, and extending mesially into the bodies of the adjacent vertebrae (Figs 143, 144).

The liver was enlarged, congested, and fatty, the spleen was pale and soft, the kidneys and suprarenals and other viscera contained no secondary deposits.

Case 2—E. T., female, age 60, was admitted on Jan 27, 1921, complaining of 'shortness of breath', she gave a history of influenza nine months previously, and from that date had complained of shortness of breath, which had been getting gradually worse. Later there was pain in the upper part of the left chest, some cough

and expectoration, the last-named thick, yellow, and with occasional streaks of blood. There had been a steady loss of weight. She had had no heart or chest trouble previously and no symptoms of dyspepsia. A maternal relative had had asthma and chronic bronchitis.

On examination, the left hemithorax was immobile on respiration, and the veins were somewhat prominent over the upper thorax. There was absolute dullness over the upper lobe in front and at the back. Tubular breathing, crepitations, and pectoriloquy were audible over a small area in the 3rd left intercostal space in front. Air-entry was diminished over the rest of the left lung. The heart was regular, normal, and not displaced. Nothing abnormal was found in the liver, spleen, or alimentary tract. The urine was normal.

On admission, the temperature was 96°, respiration 32, pulse 100. While in hospital she slept badly, and became very dyspnoeic



FIG 145.—*Case 2*. Section of left lung. The tumour is a columnar celled carcinoma in which the columnar cells are lying in spaces of various sizes. The lining cells are only one layer thick, and definitely columnar in type but have no cilia. There is a dense fibrous supporting stroma containing blood vessels.

on the least effort. On Feb 9 there was a slight rise of temperature to 99.6°, with respirations 40 to 44, and pulse of 100 to 110. The whole of the left lung was dull on percussion, and there was almost a complete absence of air-entry into the lower lobe. Heart-sounds were remarkably loud, and audible over the whole of the left chest. The right lung presented the signs of early passive congestion. Two days later she was very weak, the signs were the same, and she was very cyanosed. She finally collapsed and died the same day, namely, fifteen days after walking into hospital. The Wassermann was negative, and the diagnosis of mediastinal neoplasm was made from the signs and symptoms. The larynx was normal.

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AUTOPSY—The body was emaciated. The left pleura showed dense adhesions all over, except at the apex, where there was a small empyema. The right pleura contained a considerable quantity of fluid. There was growth under the sternum extending along the 2nd and 3rd ribs on the left side. The left lung was completely solid with growth, the right lung was partially infiltrated with growth. The peritoneum was studded with nodules of new growth, there was no free fluid.

Microscopical Report—Columnar-celled carcinoma of bronchus (*Fig 145*)

Case 3—J A F, male, age 53, was admitted on March 18, 1920, complaining of acute pain in the left side of the trunk and extending down into the left leg. He gave the following history: Rapid onset of acute pain in the left side and epigastrium, with vomiting. He also had shortness of breath and a slight cough, but no expectoration. He went to bed after four weeks, but did not improve. The neuralgic character of the pain was very distressing. After remaining a month in bed without any improvement he was admitted to hospital. He had suffered from chronic bronchitis for many years, and thought he had developed 'heart trouble' during the war. Moderate smoker. His father died of asthma with chronic bronchitis. No other family history of pulmonary disease.

On examination, there was shortness of breath and thirst but no marked emaciation. Pulse 92, respiration 20, temperature 99.5°. The heart was enlarged to the left, the apex being in the 5th space half an inch outside the nipple line, and there was marked pulsation in the 3rd, 4th, and 5th left intercostal spaces. In the precordial areas the cardiac sounds were rather tic-tac, but no bruits were present. There was a flat note over the whole of the left lung in front, with a diminution in vocal fremitus. Vocal resonance was increased, and breath-sounds were bronchial in type. A few rhonchi were audible in the upper lobe. At the back there was absence of vocal fremitus and greatly diminished air-entry, but there were no adventitious sounds. The right lung was apparently normal, and there was no sputum. The alimentary tract was apparently normal. Although there were no urinary symptoms, the urine contained blood and pus.

On March 22 there was a marked leucocytosis with a relative increase of the polymorphonuclear cells. The left chest was now quite dull, and paracentesis thoracis was performed, but no pus or fluid was obtained. The patient developed large purpuric patches on the hands, which cleared up in a few days. He gradually sank, dyspnoea became marked, with drowsiness and cyanosis, the pain improved and latterly disappeared. The left lung became stony dull, and there was complete absence of breath-sounds. The temperature throughout presented morning and evening remissions of 3 to 4 degrees. Respiration 28 to 36, and pulse 120 to 130. The Wassermann was negative.

AUTOPSY—The body was well nourished, and a nodule of growth the size of a tangerine orange was seen on the outer side of the 7th rib on the right side. Blood-stained fluid was found in both pleural cavities.

The left lung showed a dense mass of growth, which appeared to have originated in the left bronchus. This bronchus was surrounded and filled with growth, and was entirely occluded. The mass extended into the left lung and pleural cavity, behind the oesophagus and between it and the trachea, and round the base of the left lung, binding it to the mediastinum, diaphragm, chest wall, and pericardium, and extending behind the diaphragm into the abdomen. The portion of the upper lobe not affected with growth showed well-marked septic pneumonia. The right lung contained a few scattered nodules of growth.

Secondary deposits were found in both suprarenals, the right kidney, and the heart.

Microscopical Report—Columnar-celled carcinoma.

Case 4—J H, female, age 71, was admitted on Jan. 22, 1923, complaining of pain in the left side of the chest, with a feeling of tightness round the upper thorax, following a cold four weeks previously. For some two months she had complained of a troublesome cough without expectoration, and shortness of breath which was greatly aggravated by cold air. About twenty-five years ago she had influenza

severely on three occasions in successive years, without any subsequent pulmonary symptoms. Her mother died of 'bronchitis', and a sister of pulmonary tuberculosis.

On examination, the respirations were 24 to 28 per minute, but there was marked dyspnoea on the least exertion. The right lung was normal except for a few scattered rhonchi. The left side of the chest was flattened slightly and its mobility impaired. There was absolute dullness on percussion over the whole of the left lung except at the apex, which was slightly resonant. Breath and voice sounds were very much diminished. The heart was normal and apparently not displaced. There was some arteriosclerosis. All other organs were normal.

On screening, there was almost complete opacity of the left pleural sac. The apex of the left lung was dull, but not completely obscured. A film taken at the same time showed an almost complete opacity of the left chest, suggesting an extensive pleural effusion. The ribs on the left side lay more obliquely, and the intercostal spaces were narrower, than on the right. The mediastinal shadow extended slightly to the right.

A leucocyte count of the blood gave 22,000 leucocytes, 80 per cent of which were polymorphonuclear cells. Paracentesis thoracis was then performed and three pints of serous fluid were withdrawn. The centrifugized deposit consisted of red blood-corpuscles and leucocytes. A diagnosis of primary pulmonary neoplasm was made.

The pleural cavity rapidly refilled, and on Feb 9 paracentesis yielded 1 pint 6 oz of a clear serous fluid containing red blood-corpuscles and numerous lymphocytes. The lung signs remained very similar until Feb 13, when paracentesis again yielded 1 pint 15 oz of clear fluid of a similar character. At this time a small enlarged gland was palpated below the outer half of the left clavicle, no other enlarged glands were observed. The Wassermann was negative, and further examination by X rays recorded no change in the appearance of the thorax. On Feb 17 laryngoscopic examination revealed complete paralysis of the left vocal cord, at this time there was evidence of pressure on the left sympathetic. On Feb 28 there were numerous rhonchi all over the whole of the right lung, with signs of some oedema of the base. The left lung remained unchanged. The patient became rapidly worse, the temperature varied between 97° and 99°, the pulse rose to between 100 and 110, and the respirations to between 30 and 40. There was no sputum, but a persistent and troublesome cough which caused her much distress. She rapidly sank, and died on March 9, twelve weeks after the first onset of symptoms necessitating medical attention.

AUTOPSY—The body was emaciated. In front of the neck of the first rib on the left side was a hard mass of new growth which had involved the sympathetic trunk. On removing the thoracic contents, the left lung was found to be adherent along the bodies of adjacent vertebrae, but had not eroded them. Opposite the 5th rib in front, the left side of the diaphragm was transversely adherent to the chest wall, below that point it was thickened and universally adherent. The right pleura and lung were normal except for a few small scars of tuberculosis at the apex. The left pleural cavity contained a blood-stained fluid. The parietal pleura was thickened, and coloured blue and white, suggesting patchy areas of new growth and chronic oedema. Under the parietal pleura the new growth was one-third of an inch thick in places. The left dome of the diaphragm formed a firm table and was quite inextensible. The left lung was completely collapsed and densely adherent to the mediastinum. There were fingerlike adhesions between the lung and the parietal pleura, at the apex, laterally between the 3rd and 5th ribs, and at the base to the pericardium and diaphragm. A few enlarged glands were found in the neighbourhood of the bifurcation of the trachea and the hilus of the left lung. The pericardium was infiltrated with new growth on the left side. Both the left recurrent laryngeal and phrenic nerves were surrounded with growth. The heart and other organs were normal, and no further metastases were observed.

Macroscopic Appearance of the Left Lung on Dissection—The lung was completely collapsed, with a small dense patch, pale yellow in appearance, situated on the pleura at the apex. The bronchi were distinctly thickened, their lumen narrowed uniformly, and filled with blood-tinged mucus. There was no evidence of any localized tumour in the lung substance.

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Microscopical Sections—These, made from the left lung and elsewhere, showed that the carcinoma had a very similar alveolar arrangement of columnar cells, each alveolus containing cells spheroidal or columnar in type, which in some instances lined the walls of the alveoli with a layer one or more cells thick, but in other cases the cells had become detached and lay free in the cavity. The columnar character of the cells was most definite in those places where there was a single layer of cells lining the walls. The alveoli varied much in size, and in places it was difficult to make out any organized arrangement of the tumour cells. The stroma was composed of fibrous tissue, which was variable in amount.

A section of the main lower bronchus showed very marked thickening of the submucosa due to infiltration with carcinoma, and the peribronchial lymphatics were filled with carcinoma cells. Where the bronchial epithelium remained intact, normal columnar ciliated epithelium was seen.

Sections of mediastinal glands and parietal pleura showed new growth with the same characteristics as in the primary lesion.

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RHABDOMYOMA OF THE UVULA WITH A COLLECTION OF CASES OF RHABDOMYOMA.

By C. NICORY, LONDON

ALTHOUGH tumours consisting of non-striated muscle (leiomyomata) are common in the uterine wall, and very occasionally appear in the ovary, prostate, and intestinal wall, growths of striped muscle are extremely rare. Rhabdomyoma was first classified as a distinct tumour by Rokitsansky,¹ who described such a growth of the testicle—possibly, teratomatous.

Two types of simple rhabdomyoma have been described—one in which the cells tend to differentiate into striated cardiac muscle and another in which the cells assume the skeletal muscle type. Rhabdomyomata of cardiac muscle are very rare, only 12 cases being on record.² They are congenital, often multiple, confined to the heart, and do not infiltrate or give rise to metastases. They are said to be always associated with abnormalities of the central nervous system, usually diffuse sclerosis of the cerebral cortex. Rhabdomyomata of skeletal muscle-cell type hardly ever get beyond the embryonic stage of development. In the slowly growing tumours fully developed muscle fibres are formed, but in the rapidly growing ones the cells are spindle-shaped and each contains a single nucleus.³ Rhabdomyomata usually have an abundant content of glycogen.⁴

New growths of the uvula are rare, with the exception of papilloma, which may be sessile or pedunculated. Other tumours which have been met with include angioma, mucous polypus, and primary carcinoma.⁵ A rhabdomyoma of the uvula is unique, so far as I have been able to ascertain.

The uvula is composed chiefly of a mass of racemose glands and connective tissue, covered by mucous membrane, and containing a slender prolongation of the *azygos uvulae* muscle in its upper part.

The tumour in the present case occurred in a well-nourished girl, age 5. The only antecedent history was some digestive trouble between the ages of six months and one year. On Nov. 7, 1921, the little patient was suffering from an attack of coryza and sore throat. On inspecting the throat the mother observed a swelling on the uvula, about the size of a small marble (4 mm. in diameter), which on further inspection proved to be increasing in size fairly rapidly.

The child was seen by me on Dec. 15, 1921. Examination of the throat revealed a round tumour about the size of a cherry (2 cm. in diameter), attached to the uvula, which appeared like a thin peduncle connecting the growth to the soft palate. The peduncle was so slender that I feared spontaneous detachment with the risk of laryngeal obstruction. On palpation, the tumour was fairly hard and painless. Dysphagia was not complained of, but on two occasions the child became very cyanosed during sleep. Lymphatic glandular enlargement was not detected. A thorough general examination revealed nothing.

Under general anaesthesia the growth was excised by cutting through the base of the uvula.

THE SPECIMEN—Microscopically, the neoplasm was of a pale-pink colour, and looked very much like an ordinary tonsil, being beset with small depressions like the crypts of the latter. On section, a fine close striation could be discerned with the naked eye, due to the muscle fibres of which it is largely composed.

Histological Report by Professor Shattock—The sections show a highly cellular sarcomatous basis, in which are distributed groups of large sarco blasts, round or slightly polygonal in form, and many with more than a single nucleus. The cytoplasm of these is finally granular (Fig 146). The sarco blasts pass into slender elongated fibres tapering at the ends and slightly undulating, the fibres tend to

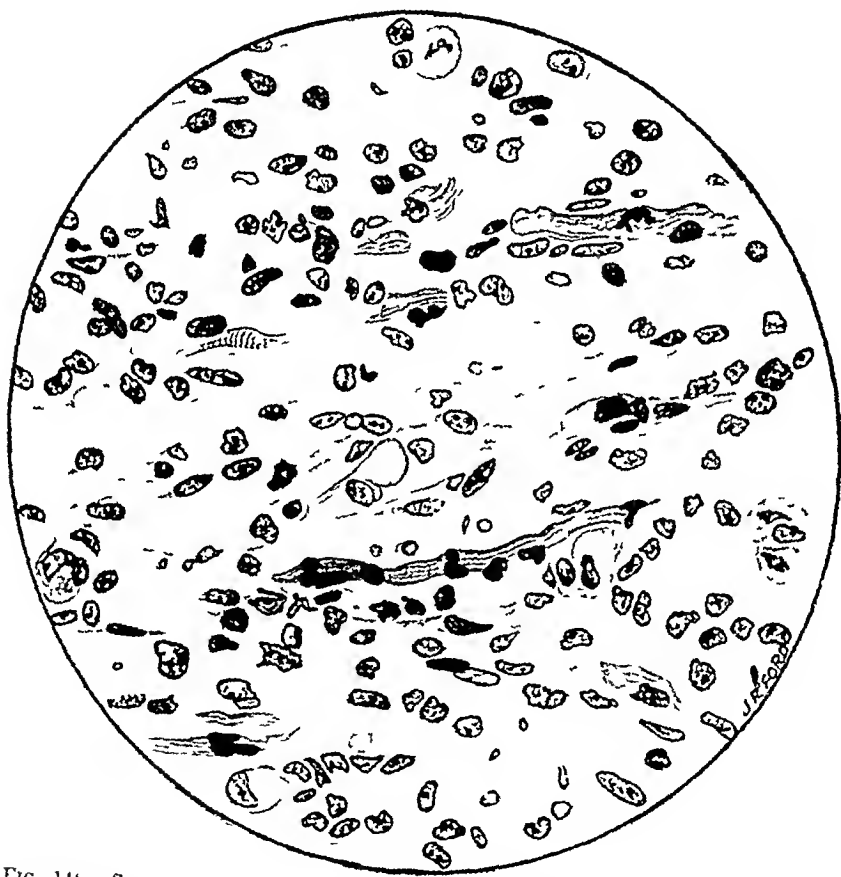


FIG 146.—Section of rhabdomyoma of uvula. Showing rounded or polygonal sarco blasts lying in a sarcomatous basis. Some of the sarco blasts have elongated into slender fibres, of which a few are distinctly cross striated. The muscular elements are stained with Congo red. (H. obj., slightly reduced.)

run in parallel strands. No fully developed fibres of normal dimensions are present, though some are distinctly transversely striated. Some of the thicker have the peculiar uneven contour such as accompanies muscular contraction. The sarco blasts vary in size, in some spots they are thickly aggregated in the sarcomatous basis. The muscular elements are readily distinguishable by their copper-red coloration with Congo red. The normal muscle fibres beyond the growth are similarly stained. The growth recurred as a small nodule in the soft palate at the base of the excised uvula and seven months later had invaded the greater part of the right side of the soft palate.

In the literature on rhabdomyoma I find three cases recorded in the lower animals—in a horse,⁶ in a codfish,⁷ and in a red lake trout.⁸ As routine microscopical examination of tumours in animals is much less frequent than in the human subject, I think I am right in assuming that such tumours may be more frequent in animals than in man.

The case described in a three-year-old-horse by Coyne and Cavalé occurred in the region of the mastoido-humeral muscle. The growth was pedunculated, mushroom-shaped, and surrounded by a fibrous capsule. Microscopical examination showed that the tumour was composed almost entirely of muscle fibres, arranged in fasciculi radiating outwards from the base of the peduncle, to be inserted in the fibrous capsule.

The authors divided the area between the peduncle and the periphery of the mushroom-shaped growth into four zones. Commencing nearest the pedicle, the neoplasm was composed of connective tissue pervaded by thick-walled blood-vessels. Further away the fibres of the connective tissue assumed a parallel arrangement, and elongated, rectangular multinucleated cells were seen, which appeared to be formed by the union of several cells. Coyne and Cavalé assumed that these were "connective-tissue cells" which had commenced transforming into striated muscle. To them they gave the name of 'elements myogenes'. In these multinucleated cells early protoplasmic changes were observed.

Formation of transversely striated muscle fibres, showing typical staining affinities, was noticed in the central protoplasm, with a corresponding pushing of the nuclei towards the periphery. At first these fibres were devoid of sarcolemma, but, as they increased in length and thickness, a definite sarcolemma made its appearance. Further towards the periphery, they described an intermediate zone consisting of fibres in the various stages of development. In the third, or zone of complete development, fibres which have reached maturity are intermingled with smaller fibres whose development has become arrested, and others showing disappearance of the transverse striation, and even Zenker's degeneration. Finally comes the zone of regression composed of degenerated fibres and hæmorrhagic infarcts. Coyne and Cavalé attributed the degeneration to compression.

This tumour was benign, and the horse resumed its work after the operation, without recurrence.

In the case described by Professor Fiebiger, of Vienna, in a codfish, the tumours were multiple. The largest was situated in the liver, having obliterated most of the hepatic substance, a second in the connective tissue between the attachments of the pylorus, and a third in the region of the tail. These growths were white in colour, very irregular, showing marked lobulation, but definitely encapsulated.

The third case is that recorded by Adam in a red lake trout. The whole neoplasm was composed of cells of the sarco-blastic type, the majority multinucleated, with a tendency to be elongated, and in parts showing cross-striation.

Two most interesting cases in which trauma was the starting-point were noted by Ludwig Buhl, of Munchen, as long ago as 1863.⁹

A servant girl, age 28, had a fall at the age of 20 and had since complained of backache. On examination, a tumour was found in the region of the lumbar vertebrae. The growth was removed by Professor Nussbaum, the operation being accompanied by very severe hæmorrhage. The pain diminished, only to return a few days later, and was followed by a rapid recurrence of the neoplasm, which, a fortnight after the operation, had reached the dimension of an infant's head, requiring a second excision.

Macroscopically, the tumour was markedly lobulated and extremely vascular. Microscopic examination revealed muscle fibres in a stroma of connective tissue very rich in newly formed blood-vessels. The capillaries ran parallel to the muscle fibres, and were so numerous in places that no room was left for any other tissue between them. These bundles of capillaries were surrounded by a connective tissue rich in nuclei, whose substance varied from a homogeneous colloidal mass to completely formed cells. The nuclei were oblong and packed closely together. Further away, the intervals between the nuclei were considerably increased, each nucleus being surrounded by a granular protoplasm and giving rise to a round or spindle-shaped cell. The nearer one got to the periphery the more elongated the cells became, and a transverse striation was noticeable in most, while others showed signs of degeneration.

The second case of Buhl's was that of a man, age 50, who, soon after an injury causing laceration of a few fibres of the pectoralis major muscle, developed a tumour at the site of trauma which attained the size of a head. Fluctuation was present, and on inserting a needle a blood-stained watery fluid was withdrawn, containing a considerable number of large lymphocytes and multinucleated cells of various sizes. The tumour, which was extirpated by Professor Nussbaum, was found to be a cyst subdivided by numerous partitions.

Histological examination of the cyst wall revealed young muscle elements, similar to those described in the first case, which when traced towards the interior showed various stages of development, until a zone was reached containing fibres indistinguishable from those of normal muscle. As the interior of the cyst was neared, the degenerating fibres became more and more numerous, until a zone of complete softening was reached. The partitions were composed of fibrous tissue and muscle substance, in a state of hyaline and fatty degeneration. It appears clear that the cyst was formed by a degeneration of muscular elements. The growth recurred locally three weeks after excision.

Buhl concludes that as a result of a pathological stimulus a muscle can commence proliferating and reproducing its various elements. Buhl has further verified this view from observations on amputation stumps, muscle abscesses, and cases of myositis, in which he noticed a proliferation of the same nature as that observed in rhabdomyomata.

In the Museum of the Royal College of Surgeons of England are two specimens, No 1420 1 and 1420 2, and in the St Thomas's Hospital Museum one, No 2163, of rhabdomyomata occurring in the urinary bladder of infants, described by Professor S. G. Shattock,¹⁰ who assigns their origin to vagrant sarco blasts which have been displaced beyond their usual deeper limits into the subepithelial tissue of the bladder from Henle's striated external sphincter.

Brock¹ has collected a number of cases of rhabdomyoma occurring in various parts of the body.

In the embryo, voluntary muscular fibres are developed from embryonic cells of the mesoderm (muscle-plate cells), which become elongated and their nuclei multiplied so as to produce long, slender, multinucleated fusiform or

cylindrical embryonic fibres. It is not quite certain whether, as has usually been supposed, the whole fibre is formed of a single enlarged cell, or whether it may be produced by the joining together end-to-end of a number of cells of the muscle plate so as to produce a syncytium from which the striated fibres make their appearance. New fibres are formed in part by a longitudinal splitting of pre-existing fibres preceded by a multiplication of nuclei. I have not been able to find any case of rhabdomyoma in which a multiplication of the muscle fibres by longitudinal splitting was noticed.

Although most authorities consider rhabdomyomata to be congenital dislocation tumours,¹¹ and others regard them as teratomatous growths, the cases recorded by Buhl seem to show definitely that a muscular injury is capable of starting a process of embryonic proliferation, with the production of fibres in all stages of development.

CONCLUSION

True rhabdomyomata, specially in early life, are probably the result of the inclusion of sarco blasts in unusual positions, but in certain cases an injury to a normal striated muscle may set up a process of embryonic proliferation, leading to the formation of a rapidly-growing muscular tumour.

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THE PATHOLOGY OF NEOPLASMS OF THE TESTIS

By A. H. SOUTHAM AND E. A. LINELL, MANCHESTER

NEOPLASMS of the testis have received considerable attention in the past and the multiplicity of classifications of these growths has led to much confusion in the terminology. It has been our aim after a careful study of the pathological features in a number of cases, to offer a simple classification which will include all the types usually met with. We hope by this means to clear up to some extent the uncertainty and confusion which at present exist in this field of pathology.

Malignant disease of the testis is relatively uncommon, and our classification is based on a series of 38 cases of neoplasm of the testis operated upon at the Manchester Royal Infirmary between the years 1908 and 1922, in addition we have collected 7 cases from other sources. The results of microscopical examination have been obtained in 21 specimens and it is upon these data that the pathological findings are based. Among 38 hospital cases, 34 occurred in the fully-descended testis, 3 were in the abdominal retained testis, and 1 was found in the inguinal canal, of the remaining 7 cases, 4 were in the fully-descended testis, 2 in the abdominal testis, and 1 was in the inguinal canal.

The comparative rarity of malignant growths of the testis is shown by the fact that only 38 cases were found among 57,000 male surgical admissions to the hospital during a period of fifteen years. That is to say, one case occurred in every 1500 male admissions to a large general hospital. It is generally admitted that malignant changes in the imperfectly descended testis are relatively more common than in the normally descended organ. Russell Howard¹ found that out of 57 cases 9 were in the retained testis. Chevassu² encountered 113 scrotal growths and 15 malignant tumours of the retained testis. Coley³ shows the ratio of malignancy in undescended to descended as 1 to 5.5. In our hospital series, 4 cases out of a total of 38 were in the imperfectly descended testis. It is of interest to note that, during the fifteen years under review, 409 cases of undescended testis were operated upon at the Royal Infirmary, whilst during the same period there was one case of malignant inguinal testis. Tanner⁴ and Bulkley⁵ both assert that the abdominally retained testis is relatively immune to malignant changes. Our series, however, does not substantiate that opinion. A history of trauma was definitely noted in three cases, and the literature appears to agree that there is a fairly sound basis for ascribing malignant changes in the testis to injury.

In considering the relatively increased frequency of malignant disease in the imperfectly descended organ, it must not be overlooked that the testis, when in the abdomen or inguinal canal, is exposed to certain abnormal

conditions which do not affect the scrotal testis. The testis in the inguinal canal is liable to suffer repeated small injuries from the constant contractions and movements of the abdominal muscles forming the inguinal region, the abdominal testis is exposed to the varying changes in intra-abdominal pressure, and is likely to be compressed when any sudden effort is made. The importance of these factors in an organ already the seat of a disturbed function and embryological defects can, of course, be only a matter for conjecture. It may be noted in this connection that malignant disease of an undescended testis that has been placed in the scrotum at an early age is practically unknown, and that no case of malignancy of the ectopic testis appears to have been recorded so far as we can discover. The relatively increased liability of the imperfectly descended testis to undergo malignant changes may depend on the fact that the organ, influenced by its unusual surroundings, is more susceptible to the effects of minor injuries and compression.

The undescended testis is an atrophic and ill-developed organ, and shows well-marked pathological changes. Such an organ is probably predisposed to malignant change, especially when subjected to constant irritation. For these reasons, therefore, operative treatment on the abdominal or inguinal testis appears always to be advisable.

As regards the gross appearance of those specimens that have come under our notice, we should say that a tumour showing multiple cysts separated by fibrous tissue is probably a teratoma, and this diagnosis would be supported by finding normal gland tissue spread over or at one pole of the cystic area. An encephaloid tumour would suggest a spermatocytoma, whilst a sarcoma appears to the naked eye as a firm, homogeneous solid growth in which localized hæmorrhagic extravasations may be visible.

There did not appear to be any special predisposition for either side to be affected. The average duration of the disease from the time it was first noticed till operation was undertaken was seven months in this series.

Classification—In a consideration of the histological nature of new growths of the testis, the confusion which exists can best be summarized by comparing the views of three recent workers on this subject. Tanner,⁴ in a series of 101 cases, found all his 97 malignant growths to be carcinomatous. Bulkley⁵ considered that of 59 cases of malignant testis, 40 were sarcomatous. Ewing⁶ made the statement some years ago that all testis tumours were teratomatous in origin, and he still holds this view with certain reservations.

It is not claimed that the small series of cases which has been collected for this paper is in any way sufficient for a statistical review, but it is considered that the material at our disposal illustrates the common types of neoplasm found in the testis, and will therefore help to stabilize the modern view of the histopathology of testis tumours. There is still a widespread view that a tumour of the testis is more likely than not to be a sarcoma, but our observations, combined with a survey of the recent literature, leads us to the opinion that such type of growth is very rare. That sarcoma does occur cannot be denied, as a purely sarcomatous structure can be seen in 2 specimens of our series of 21 cases, 17 cases are, however, definitely carcinomatous in type, and the remaining 2 are innocent tumours.

Tumours of the testis may be classified as follows —

I *Innocent*

- 1 Teratoma
- 2 Mixed-cell tumour

II *Malignant*

- | | | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|----------------------------------------------------------------------------------------|
| <ol style="list-style-type: none"> 1 Carcinomata <ol style="list-style-type: none"> a Spheroidal-celled carcinoma b Spermatocytoma c Chorion-epithelioma 2 Sarcoma | } | Epithelial tumours and therefore to be classified under general heading of carcinomata |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|----------------------------------------------------------------------------------------|

Of these types, all are to be found in our series and it is thought that a description of each type accompanied by the evidence of microphotographs will help to clarify the position

I INNOCENT TUMOURS

1 **Teratoma** (Fibrocytic Disease)—This is the commonest of the histologically innocent growths of the testis. It is generally considered that this tumour arises from a parthenogenetically fertilized generative cell and thus shows microscopically derivatives from the three primary cell-layers of the embryo—epiblast, mesoblast, and hypoblast.

Macroscopically, this tumour consists of a mass of cystic spaces in the testis varying in size from the limits of visibility to the diameter of a marble. The intercystic portion of the tumour is made up of fibrous tissue and the combined appearance gave rise to the old name for this growth, 'fibrocystic disease'. A portion of normal testicular tissue can be seen spread over or at one pole of the growth.

Microscopically, as the photographs of a typical specimen show (*Figs 147, 148, 149, 150*), the main mass of the tumour consists of dense fibrous tissue. Two distinct types of cyst are present, lined respectively by squamous and columnar epithelium, thus showing the epiblastic and hypoblastic elements of the growth. In addition to the fibrous tissue, other elements of mesoblastic origin will be seen in patches of involuntary muscle fibres. Nicholson⁷ considers that the epiblastic elements tend to predominate in ovarian teratomata, and it is an undoubted fact that in the ovary the cysts are more likely to be lined by squamous epithelium, and that more fully formed epithelial elements such as teeth and hair are more frequently found in them. The cysts in the ovarian tumour also tend to become much larger.

There seems no reason to doubt, both from clinical and microscopic evidence, that these innocent tumours may at any time become histologically malignant, the malignant change taking place in any or all of the primitive elements. Consequently such a tumour may show malignancy, becoming a squamous- or columnar-celled carcinoma, a sarcoma, or a mixed carcinoma-sarcoma. Malignant degeneration of the mesothelial elements is extremely rare and some authorities deny its possibility.

It also seems probable that a teratoma, while histologically innocent, may show metastasis in distant parts of the body. In this connection it is



FIG 147—*Teratoma* Cyst wall lined by stratified squamous epithelium ($\frac{2}{3}$ obj)

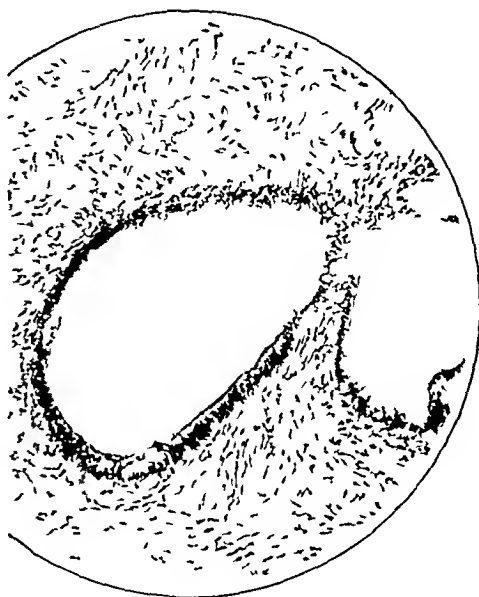


FIG 148—*Teratoma* Cysts lined by columnar and squamous epithelium Fibrous tissue matrix ($\frac{2}{3}$ obj)

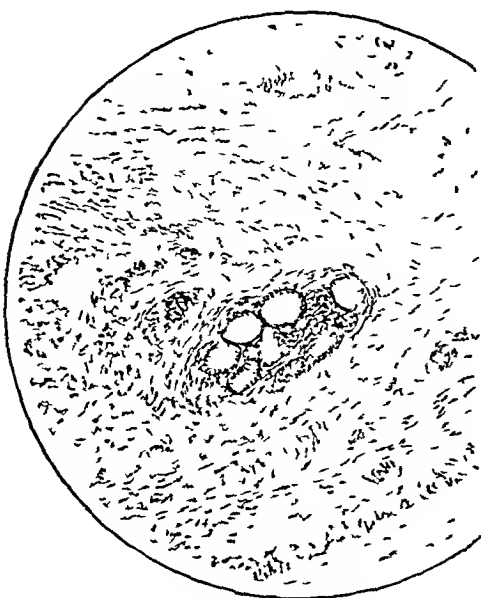


FIG 149—*Teratoma* Primitive adenomatous tissue Fibrous tissue matrix ($\frac{2}{3}$ obj)

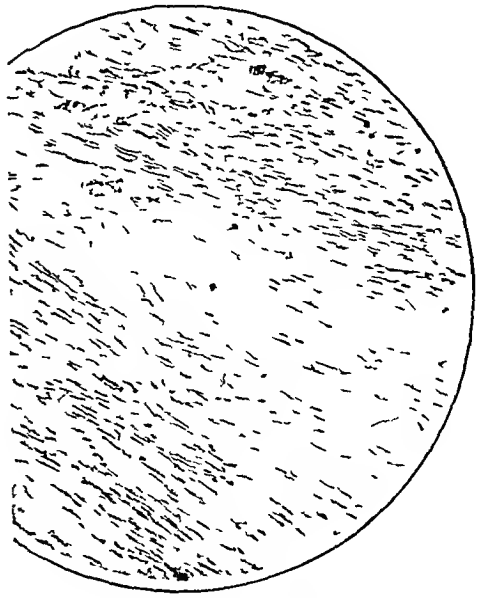


FIG 150—*Teratoma* Involuntary muscle fibres ($\frac{2}{3}$ obj)

interesting to note that Nicholson⁷ in 1907 was enabled to re-examine Kauthack and Pigg's⁸ section of Paget's famous specimen of 'malignant enchondroma of the testis'. His conclusions are that while cartilage was the principal element of the tumour epiblastic and hypoblastic epithelium could be found either in the primary growth or in its metastases. The tumour is therefore teratomatous and metastasis was through the blood-stream by rupture of the growth into a radicle of the spermatic vein. The metastases were histologically innocent in type, and this careful re-examination is of great interest as showing the possibility of metastatic spread of a teratoma.

2 Mixed-cell Tumour—This growth is rare, but as a typical case occurred in this series, the tumour is worthy of description. The neoplasm

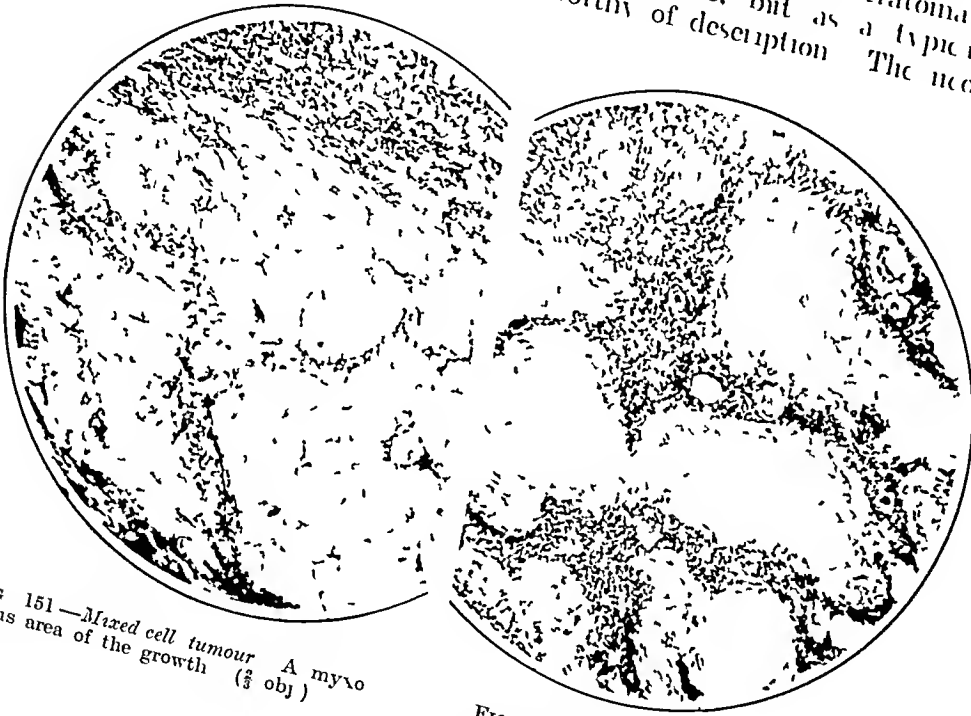


FIG 151—Mixed cell tumour. A myxomatous area of the growth ($\frac{2}{3}$ obj.)

FIG 152—Mixed cell tumour. Shows areas of hyaline cartilage separated by pavement arrangement of endothelial cells ($\frac{2}{3}$ obj.)

is identical with the myxo-chondio-endothelioma found so frequently in the parotid gland. A glance at the microphotographs of our specimen (Figs 151, 152) shows very beautifully the three elements of such a growth. As in the parotid, the tumour is encapsuled, does not form metastases, and, on account of the simplicity of its removal, the prognosis is good. It is of interest to note here that a similar tumour in the parotid tends to be due to the fact that outlying nodules of growth in the parotid tend to break through the fibrous capsule of the main tumour mass and so are apt to be left behind if the tumour is merely enucleated. The introduction of a tube of radium into the tumour bed after enucleation has improved the operative results.

II MALIGNANT TUMOURS

Carcinomata —

a SPHEROIDAL-CELLED CARCINOMA (*Figs 153, 154*)—This comes second in frequency of all types of tumour found in the testis. Tannai found 35 per cent of the 101 tumours he recently collected to be of this type. Schultz and Eisendiat⁹ give its age-incidence as 26.3 years. These three authors are united in giving this growth the name of embryonal carcinoma on the assumption that it arises from the malignant degeneration of one or other of the epithelial elements of a teratoma. *Fig 153* would seem to support this view. It will be seen that the carcinomatous masses are placed round a cyst lined by one layer of cubical epithelium, and that a cyst lined by

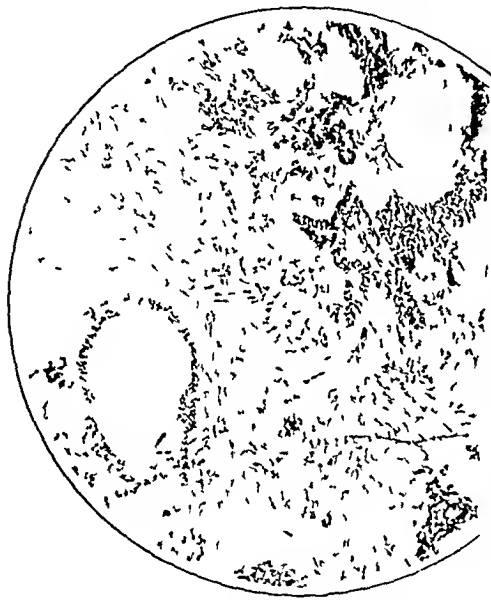


FIG 153 — *Spheroidal celled carcinoma*
Masses of infiltrating carcinoma cells arising in relation to a cyst lined by low cuboidal epithelium. A cyst lined by stratified squamous epithelium is also seen in the field ($\frac{1}{2}$ obj.)



FIG 154 — *Spheroidal celled carcinoma*
'Scirrhus' type of tumour. Blocks of carcinoma cells in the midst of well-formed fibrous tissue ($\frac{1}{2}$ obj.)

squamous epithelium is present in the same microscopic field. These carcinomata are scirrhus in type (*Fig 154*), the masses of malignant epithelium being placed in the midst of well-formed fibrous tissue.

b SPERMATOCYTOMA (*Figs 155, 156, 157, 158*)—This is the most common of all tumours of the testis. In the 101 cases collected by Tannai 62 occurred, and it will be useful to give here Tannai's complete analysis. Of 101 cases 4 were benign, 35 embryonal carcinoma, 62 spermatocytoma. The points of note in these figures are the large preponderance of spermatocytoma, and the complete absence of sarcoma from the series.

The tumour is usefully named, as showing its origin from the germinal 'epithelium'.



FIG 155—*Spermatocytoma* Shows early stage Seminiferous tubules packed with proliferated malignant germinal cells but alveolar arrangement of testis has not yet been completely lost ($\frac{2}{3}$ obj)

FIG 156—*Spermatocytoma* No trace of alveoli Absence of fibrous reticulum Well formed blood vessels Cf Fig 160 ($\frac{2}{3}$ obj)

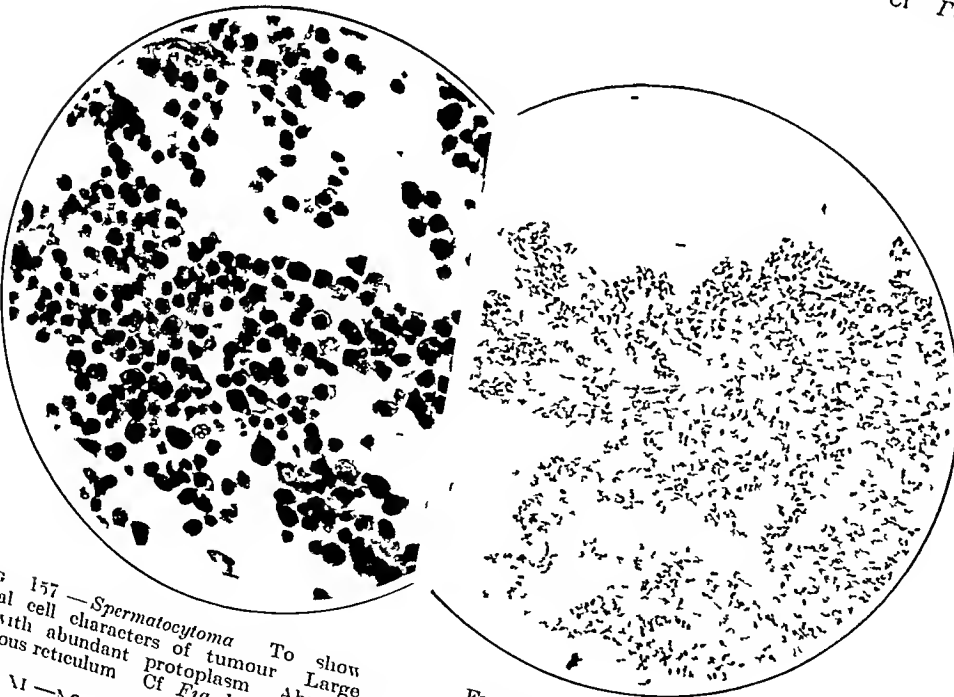


FIG 157—*Spermatocytoma* To show general cell characters of tumour Large cells with abundant protoplasm Large absence of fibrous reticulum Cf Fig 161 ($\frac{1}{2}$ obj)

FIG 158—*Spermatocytoma* Shows 'en-cephaloid' nature of tumour ($\frac{2}{3}$ obj)

The neoplasm is extremely rapid in its growth, as would be expected in view of the abundant activity of the cell from which it arises. Its age-incidence is later than that of the spheroidal-celled tumour,⁹ but is still well within the limits of vigorous sexual activity.

Macroscopically, the growth is encephaloid in type, and from its naked-eye appearance would doubtless in the majority of cases be considered sarcomatous in nature.

Microscopically, however, the tumour is seen to consist of masses of large rounded cells with abundant protoplasm and large, round, well-defined nuclei. The nuclei do not stain as deeply as do those of a sarcoma cell. The cell masses show no supporting reticulum of fine fibrous tissue, the blood-vessels in the tumour are well formed, and few hæmorrhages into the masses of growth can be discovered. An interesting feature is the number of tumour-cells containing eosinophil granules, as this point has been considerably stressed lately in the diagnosis of the carcinoma-cell. The general appearance, therefore, is in all points in favour of a tumour of epithelial origin. One of our sections is valuable as showing the early stage of a spermatocytoma (*Fig 155*), where the alveolar arrangement of seminiferous tubules has not yet been lost, and the tremendous proliferation of the malignant germinal cells is seen at its site of origin.

It is quite certain that these tumours in the past have been diagnosed as sarcomata, and the main object of this paper is to show as clearly as possible by the proof of the microphotograph that they are epithelial in type and arise from the germinal cells of the seminiferous tubules. It is remarkable, in reviewing the literature of reported 'sarcomas' of the testis, that very few seem to be beyond criticism histologically.

Bulkley⁵ reports 40 out of 59 tumours of retained testis as sarcomatous. He had two personal cases, only one of which was examined histologically. He publishes microphotographs of this and, although areas of the tumour look sarcomatous, there are parts of the growth in which the cells are spermatocyte in type. Giant¹⁰ also publishes microphotographs of an intra-abdominal sarcoma. This tumour, as he acknowledges, also shows sarcomatous areas. It would appear, therefore, that although sarcoma does occur in the testis it is the rarest of all testis tumours, and that the majority of growths formerly diagnosed as sarcoma are epithelial in type and, in view of their place of origin, may conveniently and correctly be classified as spermatocytomata.

c CHORION-EPITHELIOMA (*Fig 159*)—Nicholson⁷ describes 4 chorion-epitheliomata in his collection of 65 cases. He has found mesoblastic and hypoblastic elements in these tumours as well as the preponderant trophoblast, and he therefore considers them to be essentially teratomata, of which a specialized form of epiblast, the trophoblast, has assumed malignant characters.

The structure is an overgrowth of trophoblast, identical with that found in the malignant hydatidiform mole arising in the placenta.

Our specimen (*Fig 159*) shows principally an overgrowth of the Langhans' layers of the trophoblast, and occurred in the midst of a teratoma of the testis.



FIG 159—*Chorion epithelioma* The margin of the cellular growth is shown invading its surrounding fibrous tissue The cells are of the Langhan's type of trophoblastic epithelium, and among the cell masses are numerous vacuoles ($\frac{3}{8}$ obj.)

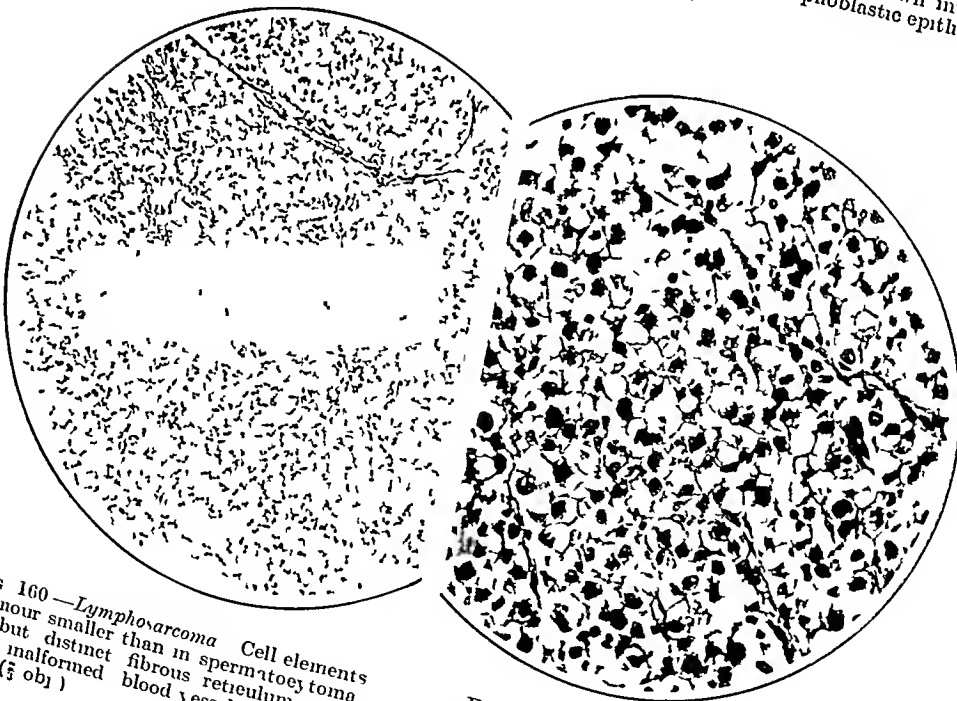


FIG 160—*Lymphosarcoma* Cell elements of tumour smaller than in spermatocytoma Fine but distinct fibrous reticulum One small malformed blood vessel present in field ($\frac{3}{8}$ obj.)

FIG 161—*Lymphosarcoma* Cell nuclei show practically no surrounding protoplasm Fine fibrous stroma well shown Cf Fig 157 ($\frac{1}{6}$ obj.)

Sarcoma—Two sarcomata are present in this series, and our analysis of the literature makes us consider this to be an unduly large number to find in such a small collection. This is due to our having included a very rare type of growth—a fibrosarcoma. It must be pointed out here that one observer has cast very grave doubts on the authenticity of the lymphosarcoma described below. He considers that the tumour cells are definitely epithelial in type, and would therefore relegate this tumour to the group of spermatocytoma.

a **LYMPHOSARCOMA**—This is probably the common type of sarcoma met with in the testis, and it shows some difficulties in diagnosis from the common spermatocytoma. The distinguishing points are that the cells are small round ones with little cytoplasm and large deeply staining nuclei. The cells are placed in a very definite reticulum of fine fibrous tissue. The vessels of the tumour are numerous and very thin-walled. There are many hæmorrhages into the growth. The microphotographs (Figs 160, 161) make these points clear.

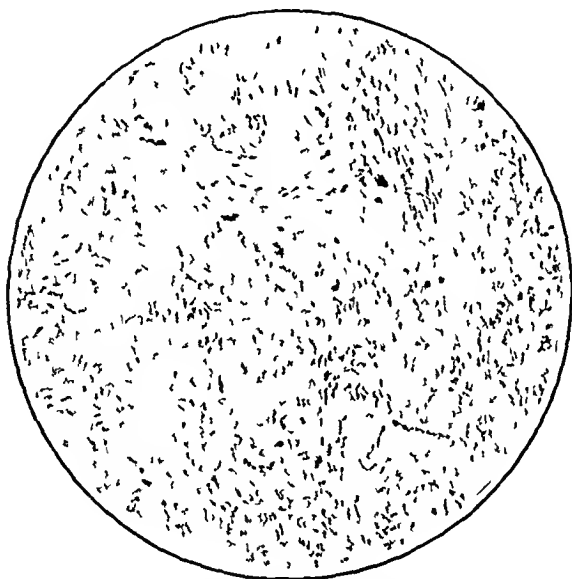


FIG 162—*Fibrosarcoma*. Section lightly stained and difficult to photograph. Fibrous tissue stroma with numerous malignant giant cells. A high power view showed these cells to contain the typical large single multilobed nucleus ($\times 601$).

b **FIBROSARCOMA** (Fig 162)—This type of tumour is so rarely found in this organ that we have been unable to discover a parallel in the literature. The section of growth shows whorls of spindle-shaped cells, malformed blood-vessels, numerous hæmorrhages into the tumour, and many malignant giant cells with the typical single large multilobed nucleus.

Our thanks are due to Professor Shaw Dunn and Dr Charles Powell White for their valuable advice and for the loan of microscope specimens for photography, and to Professor Stopford for permission to prepare the microphotographs in the Anatomical Department of the University of Manchester.

PATHOLOGY OF NEOPLASMS OF TESTIS 233

SUMMARY

- 1 Malignant disease of the testis is comparatively rare and occurs about once in 1500 surgical male admissions to hospital
- 2 In 45 collected cases, 7 occurred in the imperfectly descended testis
- 3 Teratoma appears to precede the appearance of malignant changes in certain cases
- 4 The commonest malignant tumour of the testis arises in germinal epithelium, and is usefully and accurately described as a spermatocytoma
- 5 Sarcoma is an extremely rare tumour of the testis, most of the growths so called being definitely epithelial in type and more correctly classified with the spermatocytomata
- 6 The carcinoma of a spheroidal-celled form is frequently found in the testis. It probably arises from a malignant metaplasia of the epiblastic or hypoblastic cell-elements of a teratoma
- 7 The age-incidence of carcinoma is 26.3 years, that of spermatocytoma 42.6 years (Schultz and Eisendrath)
- 8 Teratoma, although histologically innocent, may form metastases and is extremely liable to malignant change
- 9 All tumours of the testis must be considered as potentially malignant growths, and require operative removal as such

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ARTHROPLASTY.*

By ERNEST W. HEY GROVES, BRISTOL

INTRODUCTION AND DEFINITION

THE term arthroplasty in its narrow sense means the reconstruction of a joint damaged by injury or disease, and implies the actual replacement of some of the essential elements of the joint. But in its broader sense it may be taken as meaning the operative mobilization of any stiff joint, and will thus include those types of excision which aim at restoring mobility.

It is quite certain that the free excision of a joint—for example, the hip—will often produce much more functional mobility than a carefully planned reconstruction. It will therefore be necessary to consider closely these two types of mobilization operations in order to determine what are the advantages of the more complicated procedure and under what circumstances it ought to be carried out.

EVIDENCE

Experimental Evidence—The most striking experimental evidence of the formation of a joint with its essential structures—capsule, synovial cavity, and articular surfaces—is obtained by the production in an animal of a pseudarthrosis after a fracture of a single bone, such as the femur, and unrestricted mobility of the part appears to be the chief factor in the production of the new joint. There is no interposition of fascia, but the ends of the bone become covered with a layer of fibrocartilage whilst they are rounded or hollowed so as to form typical joint surfaces. And more remarkable still is the formation of a strong capsular ligament out of mere scar tissue, together with glairy synovial fluid similar to that present in true joints. This affords conclusive proof that all the elements necessary for a joint can be formed *de novo* without any elaborate plastic operation under the influence of constant movement. But it should be noted further that this pseudarthrosis has always two bad features as compared with the normal joints. In the first place it has an undue mobility, or, in other words, it is a flail-joint quite unsuitable for weight bearing, and secondly it always develops the features of osteo-arthritis in the eburnation of the articular surfaces and the production of hypertrophic fingers or actual loose bodies.

The more elaborate types of experiment in which joints are excised and then re-fashioned are of only limited value in relation to clinical phenomena, because they do not reproduce the diseased conditions which in human surgery precede the operation of arthroplasty. Such experiments merely serve to

* Read at the sixth meeting of the International Society of Surgery in London on July 18, 1923.

demonstrate how various animal membranes, whether autoplasmic or heteroplasmic, behave as lining membranes for the new joint

Foreign membranes, such as those of Caird or Baci, appear to promote excessive tissue reaction, that is to say they are attacked by tissue cells, and in the process of their absorption and removal a degree of inflammation is set up which is liable to lead to adhesions in the joint

As regards the relative value of various autogenous membranes—e.g., fascia, free or pedicled, fat, or muscle—experiment shows that there is not any clear advantage of any one of these over the others. In successful cases the new joint is found to be lined with smooth fibrous tissue, but it is much open to question whether this tissue is really derived from the transplanted membrane or whether it is not the product of the underlying bone, the covering of which has served merely as a temporary limiting membrane

Clinical Evidence—The clinical evidence about arthroplasty has accumulated very slowly in this country. This is not due merely to natural conservatism on our part but also to conflict of evidence about the results of the operation as done elsewhere. This conflict of evidence is not to be discovered so much in the published literature as in the personal exchange of views which takes place in surgical clubs

Thus ten years ago, after Murphy had described his methods of operative mobilization of the hip- and knee-joints, British surgeons were prepared to give good trial to a method which promised so much. Everyone felt that the operation upon the hip was a less risky proceeding than that upon the knee, and therefore the Murphy operation was tried chiefly upon the former joint, but the results were disappointing rather than encouraging. The operation was one of considerable severity and was accompanied by serious mortality. The majority of those who recovered had only a very limited degree of movement, and the functional result usually tended to get worse with the lapse of time. Therefore the operation has been abandoned by most surgeons, and there have been but few who have felt justified in proceeding to the operation upon the knee. Further, we have been greatly impressed with the slow progress that the operation has made in America itself. Not only has there been a remarkable absence of papers giving late results in consecutive cases, but personal conversation with American surgeons leads one to think that they too have been disappointed and that Murphy's operation upon the hip and knee has few successes to show, but many stiff hips or flail-knees

Since 1917, however, and especially during recent years, many British surgeons have been led to reconsider their sceptical or hostile attitude in this matter by the work and publications of Professor Putti. In a tentative way special cases have been submitted to operation, and some measure of success has been obtained, but opinion on the whole is undecided both as regards methods, indications, and results

INDICATIONS

In general terms arthroplasty is indicated for any ankylosed joint when the function of the limb concerned is seriously impaired and when that impairment may be improved by such mobility as can be attained by the operation

Thus at the very outset we are faced with the difficulty of deciding beforehand what functional result the operation is likely to produce. Arthroplasty can never create a normal joint, and the average result is a gain in mobility at the expense of strength and precision. In any given case the question is: Will the abnormal joint produced by the arthroplasty be more serviceable than the stiff limb which it is proposed to treat? In answering this question it will be convenient to consider the factors concerned under three headings, namely (1) *The nature of the causative disease*, (2) *The nature of the disability*, and (3) *The circumstances of the patient*.

1 The Nature of the Causative Disease—The following are the chief conditions which have to be considered —

<i>a</i> Trauma	<i>d</i> Tubercle
<i>b</i> Pyæmia	<i>e</i> Osteo-arthritis
<i>c</i> Gonorrhœa	<i>f</i> Rheumatoid arthritis

These causative conditions are arranged in the order of their suitability for treatment by arthroplasty, but such an arrangement requires several qualifying explanations. The ideal condition which promises the best results is complete bony ankylosis with normal bones and muscles, free from infection and pain. Such a condition is more likely to be produced by trauma than by anything else, but it may also arise from pyæmia, gonorrhœa, or tubercle when the disease has long been cured.

The suitability for operation in any such case must be determined by the completion of recovery from the infection and the integrity of the bones and soft parts.

In such a disease as tuberculosis (*Figs 163, 164*) it is not possible to include or exclude all cases of ankylosis of a given joint in this consideration. The majority are unsuitable because of the latency of the infection and the deep involvement of the bone-ends, but in exceptional cases, where the disease has been almost confined to the synovial membrane, and the bones are dense and firm, a good result may be expected.

A factor of great importance is the condition of the chief muscles which control the joint. If the flexors and extensors are well nourished, free from toxic atrophy or traumatic searing, then there is good hope of a strong joint resulting from a mobilizing operation. In the knee, for example, the condition of the quadriceps as regards nutrition and freedom from adhesions is the most important indication as to the probable degree of success possible for an arthroplasty.

Figs 165 and 166 are from a remarkable case illustrating several points. First it will be noted how good is this man's muscular development. He is now able to work in an engineer's shop. He had a bony ankylosis of the elbow resulting from a gunshot wound. At the operation a sequestrum was found lying in a pus cavity, and nothing therefore was done except an excision and the joint was put up in a plaster cast in full flexion with a window diameter. In spite of a most stormy convalescence, he ultimately made a complete recovery, and serves as a good example of what may sometimes result from a simple excision without any provision of a new living to the joint.

Osteo-arthritis and rheumatoid arthritis are different from all other conditions under consideration, because they seldom cause bony ankylosis, but are the cause of very crippling pain. The probability of success in such



FIG 163—Result of arthroplasty by the method described in the text. An officer who had developed a quiet tuberculous ankylosis without any suppuration. Flexion six months after operation.



FIG 164—Same case as Fig 163. Extension after operation.

cases will be much less than in the former group, but on the other hand the condition of the patient will be such that he will be content with a smaller degree of improvement. Thus it may be said that ankylosis resulting from

trauma, pyæmia or gonorrhœa in which infection is at an end, are the best cases for arthroplasty, whilst selected cases of tubercle, osteo-arthritis, and rheumatoid arthritis will also afford a considerable measure of success



FIG 165 —Case of traumatic ankylosis in which an excellent result was obtained by simple excision in spite of violent suppuration



FIG 166 —Same case as Fig 165, showing voluntary extension

2 The Nature of the Functional Impairment—Every case of ankylosed joint necessarily implies loss of function, but this loss may be trivial or severe according to circumstances. If ankylosis has taken place in good position and

is bony and painless it is better to leave it alone unless mobility will render it possible for the patient to carry out his occupation which the stiff joint prevents. But if the ankylosis is in bad position, if it is painful and the deformity progressive so that an operation is imperative, the choice has to be made between operative fixation and operative mobilization. If the joint lesion is multiple, then mobilization of some sort or degree may be imperative. For example, associated ankylosis of the hip and knee on the same leg demands mobilization of the hip, whilst ankylosis of both knees will require that arthroplasty should be done for at least one of the stiff joints.

A sharp distinction must be drawn between the upper and lower limbs as regards the indications for arthroplasty. In the former mobility is often more important than strength, but in the latter strength and stability are essential and cannot be sacrificed. This is particularly true of the knee-joint, and the opinion in this country still is that bony ankylosis of the knee in good position should not be interfered with unless it is present on both sides.

3—The Circumstances of the Patient—A successful result in arthroplasty can only be achieved with the intelligent co-operation of the patient. It is therefore always necessary to take into account those circumstances which will influence this factor of success. The disease or causative condition must be of such long duration that a permanent condition of fixation has been reached so that it is clear to the patient that the operation is the only alternative to permanent fixation of the joint. Youth is entirely favourable to arthroplasty, only provided that growth of the bones has come to an end. Keen desire for recovery on the part of the patient will be of great assistance in carrying out after-treatment and in obtaining a good result. He must understand the object aimed at and be prepared to do his share in bringing this about. It is useless to operate upon professional invalids or upon workmen who do not want to return to work.

ANALYSIS OF THE PROBLEM

Before describing methods of arthroplasty in individual joints, it may be well to attempt to analyse the various factors in the problem so that we may assign a proportionate importance to each. For the sake of simplicity we may consider that there are six essentials to be aimed at in the making of a new joint. These are as follows: (1) *To make a sufficient gap between the bone-ends*, (2) *To shape the articular ends*, (3) *To cover the articular ends*, (4) *To provide synovial fluid*, (5) *To provide ligaments and prevent undue mobility*, (6) *To restore function*.

1 To Make the Gap—This must be the first essential of all methods, whether the case is one of bony or of fibrous ankylosis. Enough bone must be removed to allow of free movement in each direction desired, and all possible fibrous tissue and especially that of inflammatory origin, must be taken away from the site of the new joint. It is usually easier to cut right through the ankylosed joint and then remove what bone and fibrous tissue is necessary from each articular end, rather than to attempt to excise the joint en bloc.

The main question here is How much bone should be removed to obtain a mobile joint? It is obvious that the wider the gap made the more likely will mobility be secured but at the same time the greater will be the danger of a flail-joint. In the old days when simple excision was the only form of arthroplasty, the wide removal of the bone was the sole device for securing mobility and preventing re-ankylosis. A consideration of such cases shows that, although free removal of bone and fibrous tissue is always essential, yet it is untrustworthy as the sole guarantee for mobility because of the danger of flail-joint which it involves. Probably the best rule to adopt is to take away enough bone at the time of the operation to allow of the full movement desired, but no more, and to trust to other measures to prevent re-fixation.

2 To Shape the Articular Ends—This is the easiest and most obvious part of the operation. The bone-ends are cut and smoothed by saw, chisel or file so as to make either a ball-and-socket or a hinge joint. In the latter case, where it is important to avoid a flail-joint, the greatest possible width must be preserved to the articular surfaces. In all cases, whether hinge or socket joint, it is better to shape one surface convex and the other concave, so as to afford more accurate fitting.

3 To Provide a Covering for the Articular Ends—This is the detail of the operation which has been subject to the greatest variation. In simple excision the bones are left to be covered with granulation tissue and the only factor which prevents the tissue of each surface joining that opposed to it is the width of the gap between the bones. Instead of leaving the bones quite raw, the cut surfaces may be rubbed with hard wax, so as to stop bleeding and to check the exuberance of granulation tissue and ultimately of fibrous tissue.

The chief merit of this procedure is its simplicity, but it is not so efficacious as the use of tissue-flaps. It is, however, a very useful adjunct to other methods. It is often convenient to cover the largest or the convex articular surface with tissue and then to rub wax into the surface of the other articular end. It is well to treat in this manner any raw bone surface which is not efficiently covered by the flap. Tissue flaps may be of foreign membrane, free fascia from the patient's own tissue, or pedicled flaps of fascia, muscle, or fat. Each has given good results but the great consensus of opinion is in favour of using free fascia taken from the patient at the time. Foreign membrane excites a certain amount of inflammatory reaction which may cause adhesion.

Pedicled flaps require a much more elaborate operation, and then blood-supply provides for more tissue exudation than occurs from free fascia. Moreover, it is often a matter of some difficulty to get the flap long and mobile enough to give an ample covering.

The fascia lata will always provide all the covering required for lining the largest joint. It probably retains its vitality when transplanted, but there is no excessive tissue reaction. It is important to cover generously all the joint surfaces which have been raw and to fix the fascia firmly. For the latter purpose it is convenient to attach the edges of the fascia to the bone itself either by small ivory nails or by sutures passed right through the bones. It is important to understand the exact rôle which is played by the

fascia introduced into the joint. The most it can do is to provide a smooth covering for the bone which will limit the formation of exudation, granulation, and fibrous tissue. It will not necessarily prevent adhesions unless a good gap has been made between the articular surfaces in the first place, and unless efficient means are taken to preserve this gap until the new synovial cavity has been established. Therefore, although good fascial covering of the bone-ends is a great aid towards mobility, it will not by itself ensure it.

4 To Provide Synovial Fluid and Prevent Adhesions.—There are two essential conditions necessary for the formation of a new synovial or bursal sac. First, there must be space preserved between the articular surfaces in which serum collects; and secondly, there must be a gliding movement to stimulate the walls of the cavity to secrete a supply of fluid, and to prevent fibrous organization. To attain these two essentials it is necessary to achieve rapid and smooth healing of the wound and to put up the limb with sufficient traction to keep the bone-ends apart. Movement must be begun early and be carried out by the patient's own muscles aided by counterbalancing or pendulum weights. Attempts to provide an artificial synovia by introducing olive oil or liquid paraffin have not been successful, probably because the wound does not provide a liquid-tight capsule, and the fluid escapes into the tissues. It is very important to secure absolute hæmostasis, because if the joint cavity becomes filled with blood-clot, organization is very likely to take place.

5 To Provide New Ligaments and Prevent Undue Mobility.—In dealing with a ball-and-socket joint, such as the hip, which is not subject to much lateral strain, the soft parts surrounding the joint, together with the remains of the original capsule, are generally sufficient to provide ligamentous control of the new joint. But in a joint such as the knee it may be a matter of grave doubt whether this is enough. As judged by published accounts, no part of the reconstruction of the joint has received such little attention as this, yet surely the ligaments are worthy of preservation or construction. In a certain sense the two ideals of mobility and stability in a new joint are opposed to one another, that is to say, certain factors which make for mobility are prejudicial to stability and vice versa. If extensive removal of bone is the chief factor upon which reliance for a mobile joint is placed then there will be grave danger of a flail-joint resulting, and conversely, if in re-making a joint the fear of instability causes a half-hearted resection, then probably only fibrous ankylosis will result. The same opposing ideas concern the treatment of the capsule or its remains as found when the joint is exposed.

To get free painless movement it is suggested that all the capsular structure should be cut away, but to get a firm joint, as much as possible of the capsule should be preserved.

This really constitutes the crux of the whole problem of arthroplasty—namely the judicious combination of mobility with stability. It is certainly unjustifiable deliberately to produce a flail-joint or to employ such a wide excision as will probably give rise to it. On the other hand, it is as well to err on the side of over-mobility, because the range of movement usually becomes less with the lapse of time, and in the case of the knee-joint it is quite possible to reconstruct the main ligaments of the joint by a later operation if the stability has been seriously compromised. This would seem

to be a wiser course than that of attempting to construct new ligaments at the time of the main operation. Not only would this unduly prolong the operation, but it would tend to prevent the early achievement of the full movement desired.

6 To Restore Function—The after-treatment is a matter of great importance. It has already been stated that the limb should be slung up with such traction as will serve to keep the joint surfaces apart whilst the new synovial cavity becomes constituted. This keeps the parts at rest without imposing absolute fixation.

When a sufficient time has elapsed for the wound to heal—about eight to ten days—then movements should be begun. The limb is slung in such a manner that no weight is borne by the patient, and then he can move the joint by his own muscles aided by a very little external force.

THE BEST POSSIBLE RESULT IN ARTHROPLASTY

Before describing methods and results in individual joints, it may be well to ask: What is the best result that arthroplasty can achieve? The best results certainly show joints which are almost functionally perfect; nevertheless they are not normal joints. The evidence for this is of three kinds. In the first place, in many cases such joints have had to be re-opened

for one reason or another, and on inspecting the new articulation no one could possibly mistake it for a normal structure (*Fig 167*). It always presents the appearance of some degree of osteo-arthritis, that is, the surface lacks a smooth covering of cartilage, the edges are heaped up as inflammatory new bone, and the bone-ends are eburnated. An objection to this may be made that these are not the results of arthroplasty, but only the failures. But even the best new joints give evi-

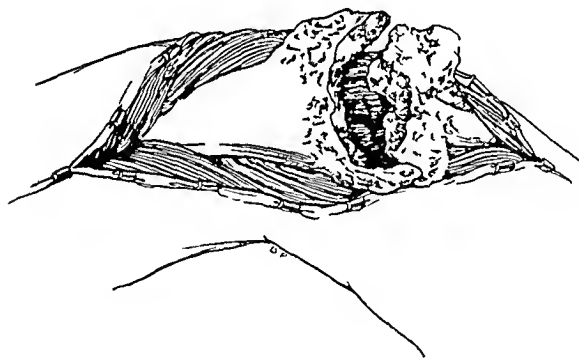


FIG 167—Bones of elbow joint three years after arthroplasty, showing marked osteo-arthritis. The bone ends were cut shaped and recovered successfully with fascia.

dence of abnormality. They grate on movement although this grating may be painless, and the X-ray shows some degree of hipping at the edges of the articular surfaces. Finally, it is unreasonable to contend that any joint can be normal when the essential element of the articular cartilage is lacking.

SPECIAL JOINTS TO BE CONSIDERED

It is proposed in the present paper to confine attention to the consideration of three large joints: (1) *The elbow*, (2) *The hip*, and (3) *The knee*.

The temporomaxillary joint is rarely affected, and its treatment does not present any special features. The shoulder-joint is very often affected, but

in this situation arthrodiesis affords such an excellent functional result that this fixation operation should be the method of choice in all cases where the scapula is mobile. In regard to the ankle the choice usually lies between an astragalectomy and amputation. The small joints of the fingers and toes are seldom operated upon with the exception of the metatarsophalangeal joint of the great toe. This is treated by the excision of the head of the metatarsal and the interposition of a flap from the bursa or soft parts covering the joint, and such an operation is very satisfactory. In regard to the finger- and thumb-joints, it must be confessed that we have been anything but successful. It is extraordinarily difficult to produce a useful mobile joint in these digits; this is due to two causes. In the first place the case is regarded as trivial, and due attention is not given to after-treatment, and in the second place, the relation of the extensor tendons to the joint is so intimate that it always becomes adherent to the structure of the reconstituted joint, so that adhesions and fixation are the ultimate result of any arthroplasty.

1 **The Elbow**—The elbow is the joint which presents the greatest scope for mobilizing operations. It is not a weight-bearing joint, and its mobility is essential for the carrying out of all occupations of ordinary life and of skilled occupations.

Mobilizing operations have been done for the elbow ever since the advent of aseptic surgery and long before the invention of the term arthroplasty. Until comparatively recently, excision of the joint with a wide removal of bone was the generally-accepted operation of choice, and it was acknowledged to be one which gave a good prospect of success.

The elbow is a joint which very frequently presents a condition of ankylosis which is favourable for a successful arthroplasty. Not only is it frequently the subject of a traumatic ankylosis, but also, when affected by tubercle, the disease is of a mild type and one which readily yields to prolonged fixation so that the bone-ends remain comparatively healthy. There is therefore, no difference of opinion as to the advisability of a mobilizing operation being done for the joint in the great majority of cases of ankylosis in adults. The only two exceptions are cases where active inflammatory disease is still present and cases of labouring men whose arms are fixed in positions in which they carry on their work.

The main question for discussion about the elbow-joint is whether the operation should take the form of a simple excision or whether flaps of soft tissue should be interposed between the bone-ends. It is not possible to give a dogmatic answer to this question, because both methods have given successes and failures. But there would seem to be very good reasons for thinking that the flap method is superior to mere excision. Excision depends for success entirely on the gap between the bones, and there is nothing except this gap to prevent fresh adhesions forming. If the gap is made large enough to make adhesions impossible then there must be a real danger of producing a flail-joint. It is true that the necessity for a big gap and the danger of adhesions may be lessened by rubbing wax into the cut bone-ends, but this is an uncertain expedient and reliance upon it will often lead to great limitation of movement.

The usual expedient employed in arthroplasty of the elbow is to shape

a pedicled flap from the tissues *in situ* and to turn this into the joint and fix it by sutures. This, too, is not altogether satisfactory, because it is not always possible to secure a flap adequate to the purpose in the mutilated limbs under consideration. Failure after the pedicled-flap operation is often in the nature of a painful ankylosis, and the reason for this is easy to understand.

A flap of soft parts has been turned into the joint and has then undergone adhesion whilst still retaining vascular and nervous connections with the surrounding structures. So that, whereas after simple excision the patient may be disappointed with the result, inasmuch as he has less movement than he expected, after the pedicled-flap operation he often comes back asking to have the elbow fixed.

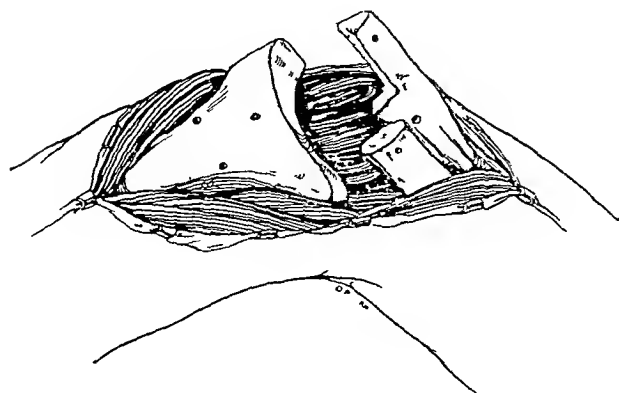


FIG. 168—Arthroplasty of elbow, showing shaping of bone ends and drilling of suture holes

because of the pain he is suffering. But if free flaps of fascia lata are taken, there will be the greatest probability of a mobile and painless joint. Moreover, the amount of fascia obtainable is amply sufficient to provide adequate covering for all three bones concerned in the elbow.

The steps of the arthroplasty for the elbow-joint are, then, as follows—

An external curved incision, turning back the skin. The triceps and periosteum are separated from the olecranon by a longitudinal incision, followed by the use of a rugine.

Separation of the soft parts from the inner condyle of the humerus, with preservation of the ulnar nerve. Division of the bone usually cutting through the lower end of the humerus. Shaping of the bone-ends.

The humerus is shaped like a Λ with as wide a surface as possible. The olecranon is preserved and its normal surface merely cut out so as to exaggerate the sigmoid notch. The radial head is removed. A careful removal of all the scar tissue round the joint, and especially that containing fragments of bony tissue. The cavity is packed with gauze whilst a piece of fascia lata about six inches long and two and a half inches

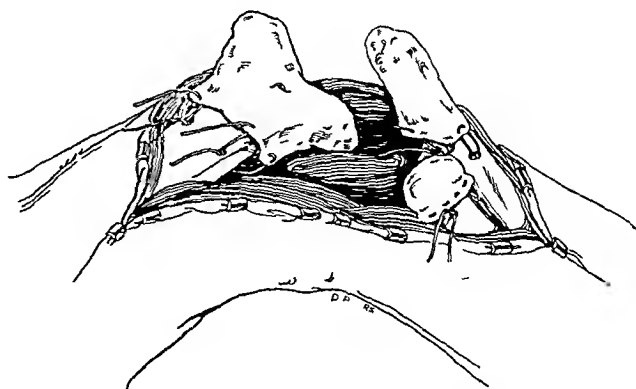


FIG. 169—Bone ends covered with fascia

wide is taken from the thigh. Suitable pieces of the fascia are wrapped round the three bone-ends so as completely to cover their raw surfaces. In order to afford secure attachment to the bones, the latter are drilled in transverse directions and the fascia is sown to the bones by kangaroo-tendon sutures passing through these drill-holes (Figs 168 169). The triceps tendon is sutured over the olecranon and the skin incision closed. The arm is slung to an overhead beam with the elbow at a right angle, the weight of the arm hanging on the hand.

2 The Hip—The hip-joint presents a much more difficult problem than the elbow, both as regards indications for arthroplasty and as to the method of operation.

First, as regards indications. Two distinct conditions have been considered: true bony ankylosis, and the limited painful fixation of osteo-arthritis. In regard to the former, it is evident that double hip-ankylosis or ankylosis of one hip in a faulty position constitute absolute indications for operative interference. In regard to stiff, painful hips, the advisability of operation must be decided by the degree of disability and the vigour of the patient. The matter is complicated by the fact that it is very difficult to produce bony fixation in these painful hips, so that this alternative is not one of practical utility. The sclerosed articular surfaces of osteo-arthritis will not form a firm union, however much their surfaces are removed. There are three conditions in the hip which may call for a mobilizing operation, and each should be treated on special lines. These are (a) *Simple bony ankylosis due to old infection*, (b) *Massive ankylosis due to trauma plus infection*, (c) *Painful osteo-arthritis and similar conditions*.

a SIMPLE ANKYLOSIS—In this condition an osteotomy of the neck will be the first step in the operation. This must then be followed by some procedure for preventing new bony union. A certain amount of bone must be removed by gouging away the head so as to form a shallow cup rounding the distal part of the femoral neck, and then turning in a flap of tissue to cover the latter.

Sir Robert Jones uses a slip cut from the great trochanter which he fixes to the cut surface of the head. Another easy device is to use the capsule which lay in front of the joint as a flap which can be turned back over the neck and sewn to the tissues behind. Both these methods give a useful and permanent degree of mobility.

b MASSIVE ANKYLOSIS—When the hip has become solidified by a big mass of bone which has resulted from injury succeeded by sepsis, it is usually wiser to leave the actual site of ankylosis and form a new joint below the line of the trochanter. If the site of the hip-joint itself is re-opened, there will not only be a danger of re-awakening latent sepsis, but the area of bone opened up is so large and vascular that troublesome bleeding takes place and the operation is fraught with great danger to the patient. Recently I have learned this lesson by losing a patient with this condition of massive ankylosis after an arthroplasty. He died within twelve hours of the operation which itself did not produce any marked degree of shock. He gradually became comatose, with failing pulse—a condition strongly suggestive of fat embolism.

It is wiser, therefore, in such cases to divide the femur below the trochanter, forming the bones in a saddle-shape and turning in a flap of fascia lata, which is very convenient for this purpose

c **OSTEO-ARTHRITIS**—For this condition the best operation seems to be a simple excision, removing the diseased bone and rounding the stump of the neck

The operation is best done by a posterior incision, splitting the fibres of the gluteus maximus, dislocating the head backwards if possible, or cutting off the head first and removing it piecemeal from the acetabulum. It is easy to turn in a flap of soft parts to cover the neck after it has been given a globular form. The posterior approach is not only easier, but it also leaves the strong anterior part of the capsule intact.

The elaborate method of arthroplasty described by Murphy has given disappointing results. It is a severe operation, because of the large bleeding surfaces. The amount of mobility gained by it in the first place is not greater than that obtained by other methods, and the final result is poor.

Whatever method of operation is employed for mobilizing the hip, it is necessary to sling the limb up to an overhead beam, with flexion and abduction of the hip, and to maintain a weight traction of about 20 lb. for the first few weeks until the patient is able to get up.

3 **The Knee**—In this country mobilizing operations upon ankylosed knees have always been regarded with scepticism. The theoretical and practical difficulties are so great and the results are so uncertain that it is not considered justifiable to advise it as an alternative to a firmly ankylosed knee in good position.

The first essential for the knee-joint is firm stability, there must be no fear of back bending and no marked lateral mobility. This stability in a normal knee depends upon the ligaments, posterior, lateral, and crucial, and of these the lateral and crucial are seriously weakened or actually destroyed by disease or the operation of arthroplasty. Again, a stiff and painless knee is much more useful than a movable knee which is in constant pain. When it is considered how little any arthroplastic joint resembles the healthy articulation and how much more it is like a morbid joint, with characters which vary between those of osteo-arthritis and those of a Charcot's joint, there is ample justification for hesitation in advising this procedure. There are two conditions which justify arthroplasty of the knee, namely, ankylosis of both knees, and ankylosis of one in a position which renders the limb useless for walking. In the latter case the usual course is to do an excision and produce a stiff leg in good position, but if the patient is willing to try for a movable joint, and if he is young and otherwise healthy, it is worth while to do an arthroplasty.

In regard to details of the operation I have but few points to urge. In general I have followed the technique described by Professor Putti. In opening the joint it seems better to divide the quadriceps tendon rather than turn up the tibial tubercle. The quadriceps will usually require to be lengthened, and this is provided for by dividing it in Z shape. In exposing the lower end of the femur all the structures at the sides of the joints are reflected by a careful raising from the surface of the bone, taking even a thin shell of

bone with them so as to preserve the maximum strength for the lateral ligaments of the future joint

The two bones are shaped so as to resemble their natural contour in a somewhat exaggerated form—that is to say, a deep notch is made between the two condyles of the femur, whilst an upstanding ridge is left on the tibia in place of the tibial spine. A large piece of fascia lata is taken, preferably I think from the thigh of the opposite leg. This must be at least 6 inches long and 3 inches wide. The knee-joint is held open in a flexed position and the fascia is made to cover the lower end of the femur, the back of the capsule and the upper end of the tibia. The two ends of the fascia thus correspond with the front edges of the articular surfaces of the femur and tibia, whilst the middle of the flap is sewn back to the posterior ligament between the two bones. Here again, it is, I think, of advantage to drill holes in the femur and tibia and to tie the fascia to the edges of the bones by kangaroo tendon.

The limb is put up slung to an overhead beam, the knee being semi-flexed, with a weight extension of about 10 lb attached to the leg below the knee. This ensures some movement from the very outset, and at the end of a week or ten days when the wound has healed active movements are begun with the aid of counterpoising weights. When the patient begins to walk, which is in about one month after the operation, he ought to have an apparatus consisting of a thigh-cage and side-irons jointed at the knee fixed into the boot.

If after from three to six months there persists so much lateral mobility that the patient cannot dispense with the apparatus, then it would seem well worth while to do a second operation for the reinforcement of the lateral ligaments. On the outer side of the joint the iliotibial band can be formed into an excellent supplementary knee ligament, whilst on the inner side the tendons of the gracilis and semitendinosus can be used similarly to make an extra internal lateral ligament.

RESULTS

For the preparation of this paper, all the surgeons of this country have been requested to furnish the results of their own experience with regard to the three joints concerned. I have had replies from almost all these, and I am greatly indebted to them for their advice and assistance. The great majority, however, state that they do not perform arthroplasty operations, thus the sum total of the material that could be collected is comparatively small, and is presented in the following tables, in which the figures from twenty surgeons are combined with those accruing in my own personal experience.

* The results given in the following tables have been made up from figures kindly supplied by the following surgeons supplemented by those of the author, and to these gentlemen I tender my most grateful thanks. J. E. Adams, W. S. Dickie, H. A. T. Fairbank, J. Fraser, G. R. Girdlestone, T. P. Legg, T. P. McMurray, G. P. Mills, J. Morley, I. P. Noble, R. Ollerenshaw, H. J. Paterson, W. H. C. Romains, C. Rowntree, A. R. Short, H. Stokes, R. A. Stoner, A. H. Tubby, G. G. Turner, G. E. Waugh.

NUMBER OF CONSECUTIVE CASES IN THE LAST 5 YEARS

LEGG	LEG	KNIF	TOTAL
94	69	19	182

CAUSE OF ANKYLOSIS IN THE CASES WHEN THIS COULD BE ASCERTAINED

	TRAUMA	INFECT	TUBERCLE	GONORRHOEA	OSTEO-ARTHRITIS
Elbow	36	9	16	1	2
Hip	6	14	11	—	26
Knee	—	11	4	—	4
Totals	42	34	31	1	32

METHOD OF OPERATION

	EXCISION		PLATE		FRIEDLAND		FORBES MEMBRANE	
	Total	Successes	Total	Successes	Total	Successes	Total	Successes
Elbow	49	21	12	9	19	6	1	1
Hip	24	9	19	5	14	6	—	—
Knee	—	—	8	2	3	1	1	2
Successes	41 per cent		41 per cent		36 per cent			

ULTIMATE RESULTS

	DEATH	GOOD	FAIR	BAD
Elbow	—	46 (49%)	27	8
Hip	3	16 (23%)	20	10
Knee	—	4 (21%)	4	10

It is clear that figures obtained by correspondence have only a limited value, but on the other hand, the fact that the tables represent the united results of the cases of twenty-one different surgeons gives a value to such

figures as representing the general measure of success obtained in this country. They permit of certain general conclusions —

1 In regard to the number of operations, the elbow has been most frequently the seat of attack, whilst the knee has only rarely been subject to mobilizing operations.

2 Gonorrhoeal arthritis has been a very rare causative condition preceding arthroplasty.

3 Successful functional results have followed excision as frequently as the use of a flap (41 per cent in each case), whereas the use of free fascia has produced a slightly lower proportion of successes (36 per cent).

4 There has been no fatality resulting from the operation except in the case of the hip-joint where the mortality has been rather over 4 per cent.

5 With regard to ultimate results, these have been best in the elbow (49 per cent), and considerably less favourable in the hip (23 per cent) and knee (21 per cent). Thus, among twenty-one British surgeons during the past five years, the chances of a stiff elbow being made functionally good have been about even with the chances of failure, whereas with the hip and with the knee the chances of improvement have been much less, only about 1 in 4 or 5.

Two facts seem to be proved beyond all doubt. The first is that arthroplasty is capable of producing almost perfect functional joints in the case of the elbow and knee. The second is that the attainment of this perfect result is the exception and not the rule.

So long as arthroplasty can only fashion joints lined by fibrous tissue it is unlikely that these results will be much improved. Probably future achievement lies in the direction of finding some way of replacing the lost articular cartilages by new cartilage grafts.

SUMMARY

1 Arthroplasty should be defined as an operative procedure upon an ankylosed joint which has the object of restoring mobility.

2 The pseudarthrosis which sometimes results from a simple fracture proves that a new joint can be formed, including fitting articular ends, capsule, and synovia without any plastic operation.

3 Clinical evidence as to the result of arthroplasty is conflicting. There is ample evidence that operative mobilization of the elbow is usually followed by greatly improved function. Arthroplasties for the hip and knee often lead to disappointment or failure.

4 The condition most favourable for arthroplasty is bony ankylosis due to trauma or pyemia which has long been cured. Certain cases of tubercle and osteoarthritis also give good results. The essential act in arthroplasty is to make a gap between the articular ends and to maintain this gap whilst healing takes place. Shaping and covering the articular ends are useful, but not essential. Continuous traction on the new articulation and early voluntary movements are the essentials of after-treatment.

5 In the elbow the indications include all cases of bony ankylosis free

from active infection, except those in which a strong, useful arm is present in a labouring man. The best operation for the elbow is to preserve the whole width of the humeral condyles and to cover this bone with a free flap of fascia lata.

6 In the hip, three different types of operation must be considered. For simple ankylosis, an osteotomy of the neck of the femur with interposition of a flap taken from the trochanter or from the capsule. For massive hypertrophic ankylosis, a subtrochanteric osteotomy with the interposition of a fascial flap, forming a saddle-shaped joint. For osteo-arthritis, excision of the head of the femur.

7 In the knee, the importance of stability and painlessness makes any mobilizing operation unjustifiable if the joint is fixed in a good position. It is only in the case of ankylosis of both knees that arthroplasty is to be considered. The use of free fascia to cover the lower end of the femur, the preservation of the lateral ligaments, and the use of a jointed knee-cape for some months after operation, are the special points on which stress must be laid. If lateral mobility persists, then the lateral and crucial ligaments must be reinforced by a second operation.

NOTE.—The above article introduced the subject of Arthroplasty at the International Society of Surgery. A critical summary of the papers and discussion which followed will be found on page 319.

ANOMALIES OF INTESTINAL ROTATION THEIR EMBRYOLOGY AND SURGICAL ASPECTS WITH REPORT OF FIVE CASES.

BY NORMAN M. DOTT, EDINBURGH

INTRODUCTION

DURING its development the abdominal portion of the alimentary canal may suffer a large variety of perversions. We are here concerned with that variety by which the disposition of its parts is interfered with. In the three main subdivisions of the alimentary canal, the incidence of essential errors of disposition is confined almost entirely to the midgut. Error in location or attachment of that part of the foregut situated within the abdomen (stomach and duodenum down to biliary papilla) is excessively rare. Error in location or attachment of the hindgut (left end of transverse colon to rectum) is also uncommon. The splenic flexure is very constant in its location, and in a review of the relative literature I have noted but two instances of gross displacement of this part (Farabœuf,¹ Mascarel²). Variations in the course of the descending and sigmoid colons constitute but minor modifications of their normal curves or degree of adhesion. Black³ has reviewed this subject, and finds only 9 records of cases in which the descending colon erred so far in its course as to reach the mid-line. The sigmoid colon is liable to great variation in length, and hence in position, but its primary attachment is remarkably constant. In the very rare condition of extroversion of the cloaca it may be noted that the hindgut is so maldeveloped as to be almost unrecognizable—it is completely misplaced (Johnston⁴).

In contrast to the rarity of true malposition of the foregut and hindgut, a brief review of the literature has furnished me with 45 records of gross developmental errors in the disposition of the midgut (the intestine from the duodenal papilla to the left third of the transverse colon). The reason for this greater frequency of error in the midgut is to be found in the more complicated evolution of its natural-disposition in the abdomen. Minor degrees of developmental misplacement of portions of the midgut are extremely common.

The surgical importance of abnormal situation of the portions of intestine derived from the midgut loop requires little comment. It is of importance to the correct diagnosis of abdominal pathology. Has not left-sided appendicitis been kept under observation with disastrous consequences when a normally placed organ would have been removed by timely operation? It is of importance at the exploratory laparotomy. Failure to recognize the nature and characteristic features of these misplacements may lead to grave errors in procedure or to injurious prolongation of the operation or to its

abandonment. It is of importance in respect of the pathology it may directly cause. The conditions directly due to gross congenital malposition of the intestines are lack of sufficient adhesion, with consequent tendency to secondary displacements, torsion, and volvulus, and less commonly excessive adhesions, leading to kinking or compression of the bowel.

The difficulties of abdominal diagnosis and of exploratory laparotomy demand special consideration in infants and the probability of direct pathological consequences of the maldevelopment is greatest in them. The condition therefore acquires an especial significance in regard to the surgery of infancy.

The three cases which have come under my own observation are distinguished by gross errors of the rotation process by which the midgut acquires its typical disposition, and by a secondary pathology leading to acute intestinal obstruction. The first was a case of congenital reversed rotation and deficient peritoneal fixation, which in old age led to torsion, kinking, and acute obstruction of the large intestine. In the second case, non-rotation with deficient peritoneal fixation predisposed to extensive volvulus with acute duodenal obstruction within five days of birth. In the third case mal-rotation with deficient peritoneal fixation led to extensive volvulus and acute duodenal obstruction within three days of birth.

In reviewing the relative literature I have selected only those records in which a fundamental error of intestinal rotation was present. Although I fully appreciate their surgical importance it is not possible to deal here with such conditions as ovi-descent, undue mobility, and defective descent of the cæcum, undue mobility of the descending colon, excessive length and undue mobility of the sigmoid loop. These conditions represent comparatively slight developmental variations, and their inclusion would entail too comprehensive a field. Complete and partial transposition of the viscera do not concern us here.

A glance over the titles of the records of the appended bibliography demonstrates clearly that there is a lack of uniformity of description and classification of the conditions dependent on fundamental errors of rotation of the midgut loop. It would appear desirable to arrive at some simple and consistent plan of nomenclature and classification. This can best be accomplished by a consideration of the embryology of the conditions, and of their secondary pathology.

EMBRYOLOGY

The first indication of the alimentary canal is the entodermic vesicle of the zygote. By a constriction the vesicle becomes divided into an intra-embryonic portion—the future alimentary canal and its appendages—and an extra-embryonic portion—the yolk sac, the intervening constriction is the vitello-intestinal duct. As the embryo elongates, the alimentary canal takes the form of a tube, and its subdivisions become apparent.

In *Fig 170* the essentials of the abdominal portion of the alimentary tract during the fifth week are schematically represented. The canal is seen to be divided into three main subdivisions, foregut, midgut, and hindgut. The subdivision is based on form—the parts constitute three distinct loops

It is based on blood-supply this is distinct for each part the coeliac axis, superior mesenteric and inferior mesenteric arteries respectively. It is largely applicable to function the foregut, digestive, the midgut absorptive, the hindgut excretory. All are suspended by the common dorsal mesentery.

The ventral mesentery of the foregut and the allantoic ventral connection of the hindgut do not concern us. The midgut has a ventral attachment, by the vitello-intestinal duct, to the yolk sac, the attachment is lost at an early period.

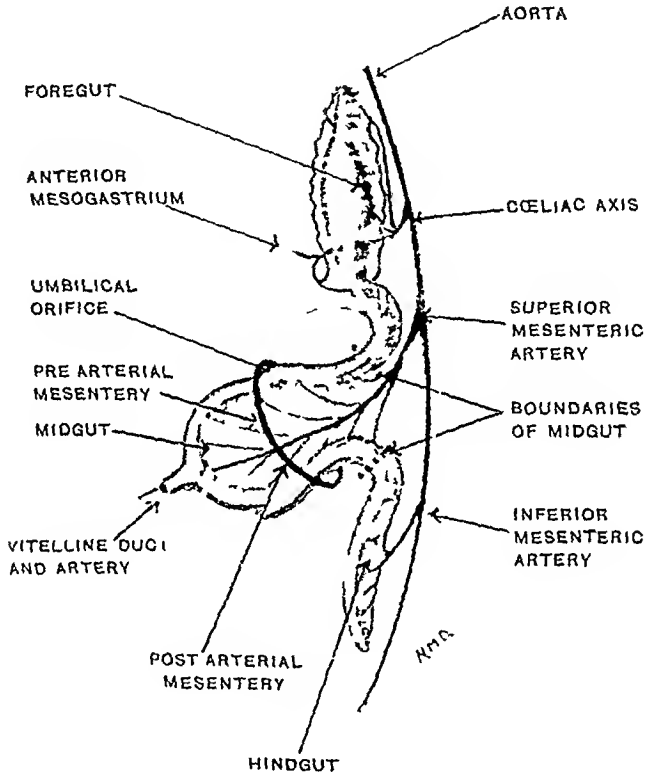


FIG. 170.—Diagram representing conditions of primitive alimentary tract at 5th week. The three main subdivisions are seen to constitute three loops—the foregut, midgut, and hindgut. The aorta is representative of the axis of the body. From it the three loops are suspended by their common mesentery in the sagittal plane. In the mesentery the special arterial supply for each loop is represented. The midgut loop is already large and has been extruded into the umbilical cord. The cecal bud is appearing.

For clearness in subsequent figures the midgut has been coloured yellow, the pre arterial mesentery green and the post arterial mesentery purple.

The abdominal portion of the foregut forms the stomach and the duodenum down to the biliary papilla. As early as the fourth week the bulging of the greater curvature of the stomach appears. The oblique direction and curved form of the organ are the result of its unequal growth. Thus the shape and posture of the stomach depend on intrinsic forces and are very constant. The upper part of the duodenum is deviated to the right by the stomach, its mesentery becomes thickened and shortened and into the latter the dorsal pancreatic rudiment grows during the fourth week. The position of the

upper part of the duodenum is equally as constant as that of the stomach, the growth of the pancreas into its mesentery is responsible for its curvature and fixation. It will thus be seen that the lower end of the foregut—that is the duodenum at the level of the biliary papilla—is, at a very early period a fixed and constant point, a little to the right of the mid-line, from which the midgut loop depends.

At first the hindgut occupies the middle line of the abdomen. From its upper end a 'retention band' (Frazer and Robbins⁵) a mesenchymal thickening in the mesentery, passes upwards to the condensed tissue about

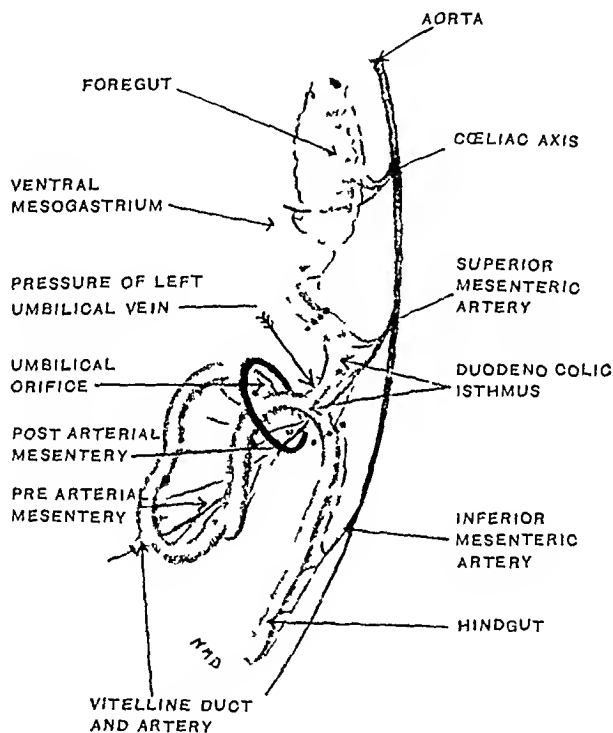


FIG 171.—Diagram representing conditions of alimentary tract about the 8th week. The first stage of rotation is being accomplished. The arrow indicates the pressure exerted by the left umbilical vein upon the prearterial segment of the loop forcing it downwards and to the right. Note the narrow duodeno-colic isthmus at the base of the loop, with the superior mesenteric artery running through it.

the origin of the superior mesenteric artery. This retention band does not keep pace in growth with the gut or mesentery, so that it forms an anchorage by which the upper end of the hindgut is relatively approximated to the origin of the artery as growth proceeds. The gut, being 'hitched up' by the band, is bent by it at the junction of midgut and hindgut, this flexure is known as the colic angle. The colic angle is, at a very early period a fixed point at the upper end of the hindgut, from which the midgut loop depends.

It will be noted that the duodenum and colic angle are close to each other, and being fixed points the growth of the embryo causes their relative

approximation, so that they form a narrow isthmus—the duodeno-colic isthmus—to which the two limbs of the midgut loop are attached

The midgut grows very rapidly in length, and forms a large loop, convex forwards. Already at the fourth week (Mall⁶) the vitello-intestinal duct has lost its connection with the yolk sac and umbilical cord. The rapid growth of the midgut loop and of the liver so diminishes the available abdominal space that the former is extruded into the root of the cord as a temporary and physiological umbilical hernia. At the apex of the herniated loop is the

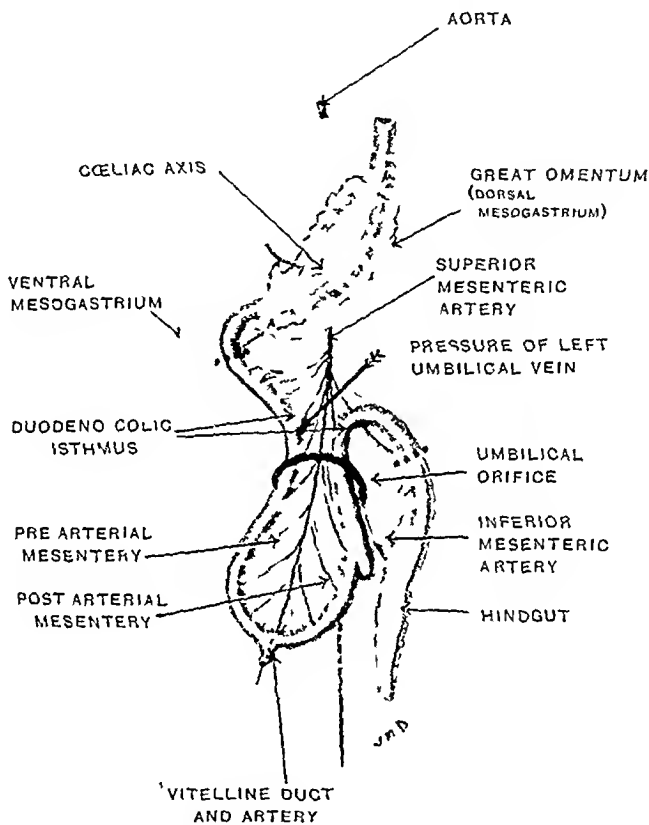


FIG. 172.—Diagram representing the same stage as preceding figure, viewed from ventral aspect. The same points are brought out. Note especially the right sided position of the small intestine and the left sided disposition of the large at this early stage of the rotation process. In the condition referred to as 'non rotation' these relations are maintained.

former site of the vitello-intestinal duct and the termination of the superior mesenteric artery—formerly the right omphalo-mesenteric artery. The vessel runs from the dorsal aorta between the closely approximated ends of the midgut loop to its apex, it lies in the mesentery of the loop, and sends branches forwards to its anterior segment and backwards to its posterior segment. The loop still lies in the sagittal plane, its anterior segment is the pre-arterial segment and its half of the mesentery the pre-arterial mesentery, the posterior segment is the post-arterial segment and its half of the mesentery

the post-arterial mesentery. During the fifth week the bud for the cæco appendix appears on the post-arterial segment of the loop.

We have now traced the development of the midgut loop up to the fifth week. It constitutes a loop of bowel projecting forwards in the sagittal plane into the umbilical cord. The base of the loop is narrow and contains the artery of supply between its closely approximated segments. The basal attachment of the pre-arterial segment is slightly to the right of the mid-line on account of its duodenal attachment. We are now in a position to study the rotation of the loop.

The first stage of rotation (Frazer and Robbins⁵) takes place while the loop lies in the umbilical cord between the fifth and tenth weeks. The second stage occurs mainly during its reduction into the abdomen at the tenth week, and is completed when the cæcum reaches the right loin at the eleventh week. The third stage progresses from that time until birth or a short time after it.

The First Stage of Rotation (Figs 171-172).—The left umbilical vein persists, the right one disappears. As the right lobe of the liver enlarges and descends, the left umbilical vein is carried downwards and to the right. As it deviates in this direction it exerts pressure upon the pre-arterial segment of the midgut loop near its base. The gut is carried downwards (caudally) and to the right. The pre- and post-arterial segments being placed side by side within the narrow circle of the umbilical orifice, the latter is naturally displaced upwards (cranially) and to the left by the former. The intestine rapidly increases in length, so that there results an S-shaped flexure, the pre-arterial segment forming the right half, and the post-arterial the left half (Fig 172). This is the first stage of rotation. Failure of rotation up to this stage occurs only in connection with extroversion of the cloaca, and the term 'non-rotation' refers to a failure in the second stage. During their stay in the umbilical cord the pre-arterial grows much more rapidly in length than does the post-arterial segment, so that the former and its mesentery become disproportionately elongated. In this way the superior mesenteric artery acquires a relatively closer relation to the post-arterial segment. The cæcum and adjacent colon have meanwhile increased in thickness, and constitute a considerable swelling upon the post-arterial segment.

The Second Stage of Rotation (Fig 173).—About the beginning of the tenth week the midgut loop is returned to the abdominal cavity. Frazer and Robbins point out that it is not possible for the bulky hernial content to return *en masse* through the narrow umbilical orifice. The cæcum especially offers resistance to this passage. They believe that the pre-arterial segment returns first, in continuity of its length basal end foremost. Fig 173 represents

* In support of this view that the cæcum is returned to the list in the hernial sac Frazer and Robbins (loc cit p 94) refer to Mull's specimen, in which the midgut loop was in process of reduction, only the cæcum remaining in the sac. Further, I note that Sir J. Y. Simpson (*Edin Med and Surg Jour*, 1839, liii, 19) reported on an anencephalic fœtus of full term, in which the cæcum and a few coils of ileum were returned in a persistent umbilical sac. Hunter (*vide infra*) records a case of great interest in this connection, in which a mesenteric cyst of the jejunum constituted a more formidable obstruction to reduction than did the cæcum. He believes that an inverted order of reduction accounted for the reversed second stage of intestinal rotation.

the small intestine (pre-arterial segment) passing through the umbilical orifice in this way. The cæcum, adjacent ileum, and colon are still in the cord, and they hold with them the termination of the superior mesenteric artery. It will thus be seen that during the return of the small intestine the artery is anchored forward to the umbilicus and is suspended across the abdomen between its origin from the aorta and the umbilicus. The small intestine

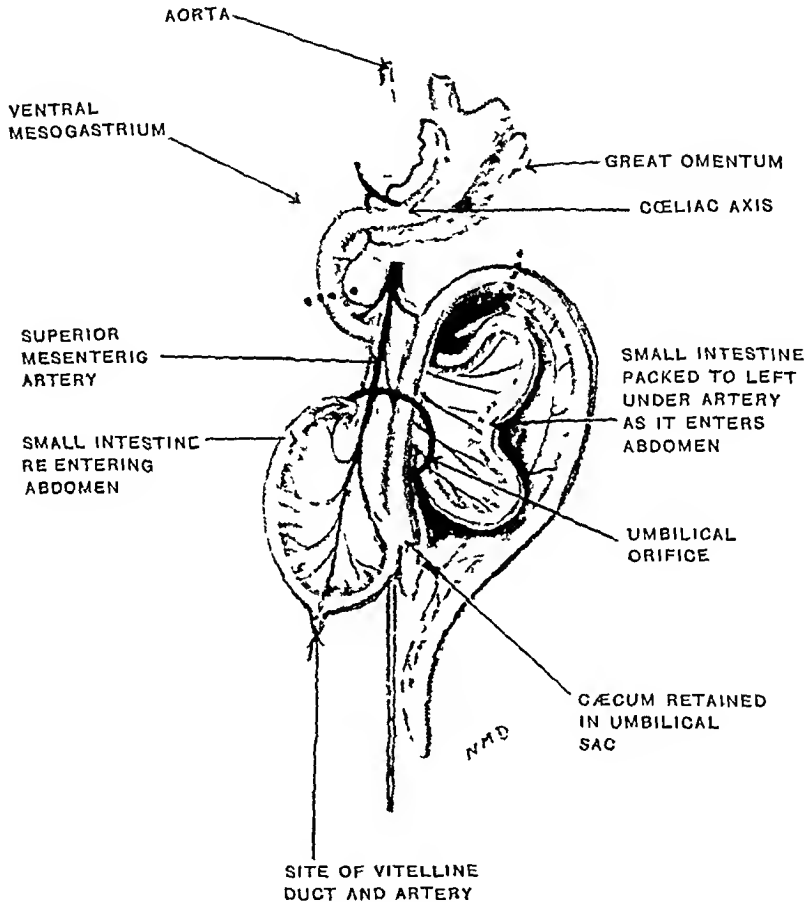


FIG. 173.—Diagram representing conditions of the alimentary tract at the 10th week. It will be seen that the pre-arterial segment of the loop—the small intestine—has increased in length disproportionately to the post-arterial segment and that its mesentery has shared its rapid growth. The cæcum and adjacent colon have grown relatively thick. The temporary umbilical hernia is in process of reduction. The small intestine is seen entering the abdomen on the right side of the superior mesenteric vessels and passing to the left side of the abdomen behind the mesenteric vessels to fill up the available space. The vessels are held forwards to the umbilicus by the cæcum which still lies in the sac. The second stage of rotation is in progress.

enters the abdomen on the right side of the artery. As its coils collect within the cavity those first reduced are pushed into the available space behind the outstretched artery by those following on. The hindgut and its mesentery which occupy the middle line are pushed before them—folded to the left and backwards (descending colon). The coils bulge upwards under the coeliac angle tending to displace it further up (splenic flexure). The last coil of the ileum

carries the superior mesenteric artery with it as it enters the abdomen. At length the cæcum is reduced. The cæcum now lies free in the region of the umbilicus on a plane anterior to the small intestine and to the mesenteric artery, from here it can pass in any direction. The colon, tending to straighten out, carries the cæcum upwards and to the right. The colon comes to lie

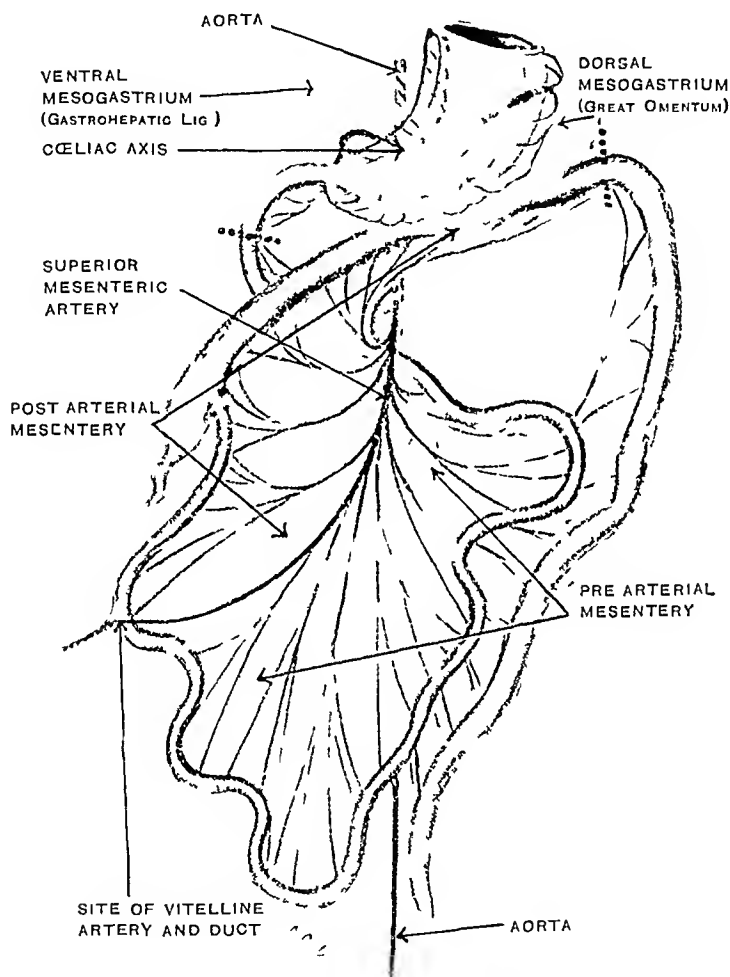


FIG. 174.—Diagram illustrating conditions of alimentary canal about the 11th week. The second stage of rotation is complete—the cæcum is now in contact with the posterior abdominal wall at the right loin. It will now be seen that the midgut loop has rotated on the axis of the superior mesenteric vessels through 270° from its original sagittal plane. The essentials of the permanent disposition of the viscera have been attained.

across the pedicle of the intestinal mass at the origin of the superior mesenteric artery, and the cæcum attains a position below the liver. Elongation of the colon causes the cæcum to descend into the right loin. The second stage of rotation is complete (*Fig. 174*). It will be noted that the ultimate result of the second stage of rotation is an anti-clockwise turn about the axis of the

superior mesenteric artery of 270° from the primitive sagittal position of the loop (not 180° as is often stated) In this way the duodenum is caused to cross behind the superior mesenteric vessels near their origin, while the colon crosses the same point anteriorly The descending colon has been folded back into the left loin, while the cæcum has attained the right loin The coils of small intestine range in orderly sequence from the left upper to the right lower regions of the abdomen

The Third Stage of Rotation —This stage is characterized by the further descent of the cæcum, and by the fixation of certain portions of the intestine to the posterior abdominal wall by fusion of their mesenteries with the posterior parietal peritoneum By elongation of the colon the cæcum is caused to descend, so that by the fifth month it has reached the level of the iliac crest The lower part of the duodenum having arrived in its retro-arterial position becomes fixed there by fusion of its mesentery with the posterior parietal peritoneum and with that of the mesenteric pedicle in front The duodeno-jejunal flexure is formed and fixed The superior mesenteric artery is directed towards the right iliac region by the migration of the cæcum to that site At about the twelfth week the mesentery becomes adherent from above downwards to the posterior abdominal wall along the line of the artery The area of adhesion spreads out towards the right until the ascending colon and cæcum become quite fixed Thus that portion of the post-arterial mesentery in relation to the cæcum, ascending colon, and hepatic flexure is entirely obliterated by fusion The post-arterial mesentery of the transverse colon persists as its mesocolon To the left of the line of adhesion along the superior mesenteric vessels the pre-arterial mesentery remains free as the mesentery of the small intestine In this way the line of fusion comes to constitute the wide, obliquely placed root of the mesentery of the small intestine The mesentery of the hindgut is completely obliterated, from its attachment along the mid-line to the left loin, by fusion with the posterior parietal peritoneum, thus the colon from the splenic flexure to the left iliac region becomes fixed A free mesentery is, of course, retained at the sigmoid flexure The practical importance of the third stage lies less in the minor degree of rotation it completes than in the fixation of the parts in such a way that displacement and especially torsion and volvulus, are rendered impossible Thus the ileocecal angle is held steady by adhesion of the cæcum and ascending colon The mass of small intestine originally dependent from a very narrow pedicle at the origin of the superior mesenteric artery acquires a wide secondary attachment along the 'root of the mesentery' and is stabilized by it

DERANGEMENTS OF INTESTINAL ROTATION

Etiology —We have seen that the first stage of rotation causes the intestine of the hindgut loop to assume an S-shaped distribution with the small intestine placed to the right of the mid-line the ileocecal junction about the mid-line and the colon entirely to the left Rotation up to this stage is never interfered with except in the presence of extorsion of the cloaca

We have seen that the chief factor which determines the second and essential stage of rotation is the sequence in which the intestine is returned

from the umbilical cord to the abdomen. A departure from this sequence of return is the only possible explanation of perversions of the second stage of rotation. Adhesions, which are sometimes found binding the intestines in their abnormal situations, have been widely credited as the essential cause of their malposition. In view of what we now know of intestinal rotation this view is untenable for the intestines could only reach their abnormal site while quite mobile and as a result of a disorderly sequence of reduction from the umbilical cord.

What factors may cause a disorderly sequence of return? The normal sequence depends on the bulk of the cæcum retaining it to the last in the hernial sac, while the more easily reduced small intestine enters the abdomen first. The factors which would derange this order are such as would render the small intestine more difficult of reduction or the cæcum easier, or the umbilical orifice so large that they could be reduced with equal facility. I have already cited the remarkable case of Hunter's⁷ in which a mesenteric cyst, attached to the jejunum acted in this way, rendering the small intestine more difficult of reduction. The cases I have to report show no abnormality which could be held responsible nor is record of such to be found in the literature with the exception of Hunter's case. An unduly wide umbilical orifice would exert no particular restraining influence upon the cæcum, and disorderly reduction might be due to this cause. Evidence as to this possibility is not available, but it seems to be the most probable abnormal factor.

The factors concerned in the third stage of rotation are elongation of the colon, causing descent of the cæcum, and adhesion and obliteration of certain portions of the mesenteries giving the intestines their natural degree of fixation. The derangements of this stage are of the nature of incomplete development. The cause of failure of completion is quite obscure.

A Derangement of the First Stage of Rotation—Failure in the first stage of intestinal rotation only occurs in relation to the rare condition of extorsion of the cloaca. In this condition the ureters, genital ducts and intestinal canal all open on the extorted area. The ileum usually opens on the surface and the large intestine is represented only by histological remnants on the extorted area. A very short intra-abdominal portion of large bowel may be present. The condition is probably due (Johnston⁴) to a rupture of the cloacal membrane at a very early period.

Development of all the structures formed from the primitive gut caudal to the vitello-intestinal duct is interfered with. The post-arterial segment of the midgut loop is therefore involved, and remains quite undeveloped. Rotation cannot occur and the pre-arterial segment, i.e., the small intestine retains its primitive position, ventral to the superior mesenteric vessels.

B Derangements of the Second Stage of Rotation—

Group 1 NON-ROTATION OF THE MIDGUT LOOP—The essential features of this condition are. The small intestine lies chiefly to the right of the mid-line, the duodenum descending from its normally fixed upper part (foregut), passes down the right side of the superior mesenteric artery. The jejunum and ileum occupy the right hypochondriac, lumbar, and iliac regions, the termination of the ileum may cross the mid-line to reach a left iliac cæcum, or it may terminate about the mid-line in a pelvic cæcum. The colon is confined to

the left side of the abdomen. The cæcum, situate in the pelvis or left iliac region, is reversed; that is, the ileum enters it from the right side. The ascending colon passes upwards from it, usually a short distance to the left of the mid-line, to reach a position behind the greater curvature of the stomach. Between this point and the normally placed splenic flexure a narrow, U shaped

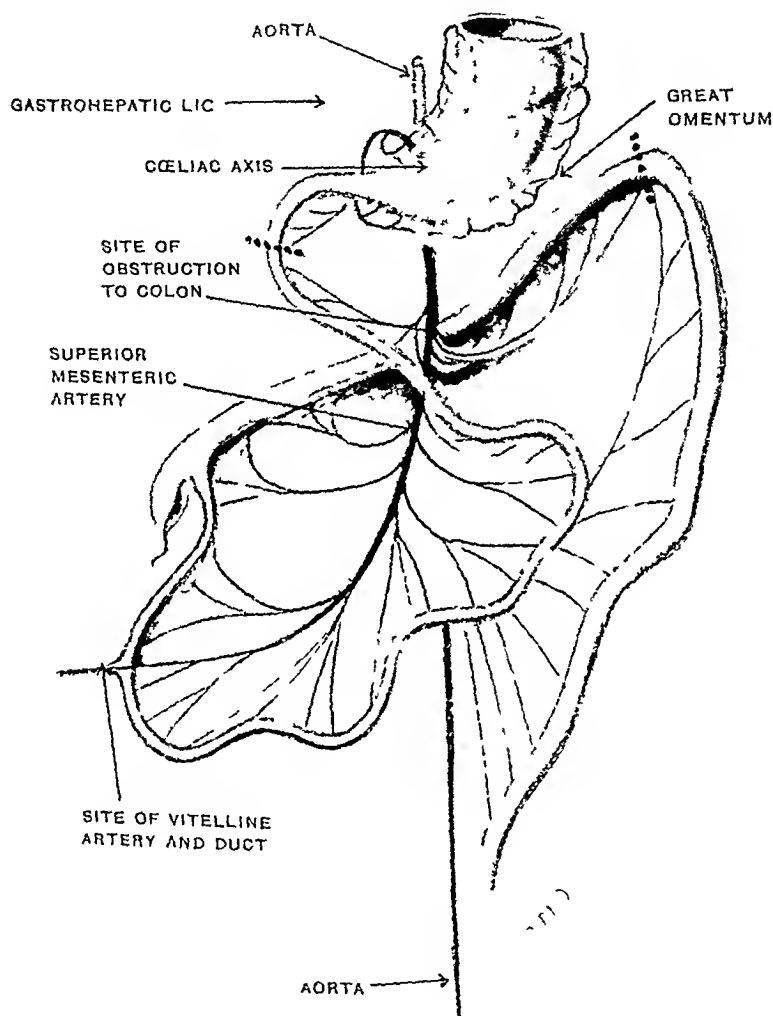


FIG. 175.—Reversed rotation of midgut loop. The midgut loop has rotated in a clockwise direction through 90° from the original sagittal plane. Thus the colon is brought to lie behind the mesenteric vessels and the duodenum in front of them. These are the only noticeable defects; the viscera otherwise attaining normal positions, though of course their anterior and posterior surfaces are reversed. (Case 1)

loop of transverse colon depends for a variable distance. The relation of the transverse colon to the great omentum is maintained normal. The descending and pelvic colons take their usual course (Intestine).

In these abnormal sites the viscera undergo a great variety of secondary fixation by mesenterial adhesion; the tendency is for fixation to be imperfect

The duodenum may be adherent at the right side of the mesenteric pedicle, or more or less free. The mesentery may adhere for a variable distance below the origin of the superior mesenteric artery, and the ascending colon may in this way acquire a short mesocolon with its attachment close to the left side of the vertebral column. The cæcum usually remains quite mobile, and is often described as suspended by a free mesentery attached over the lower

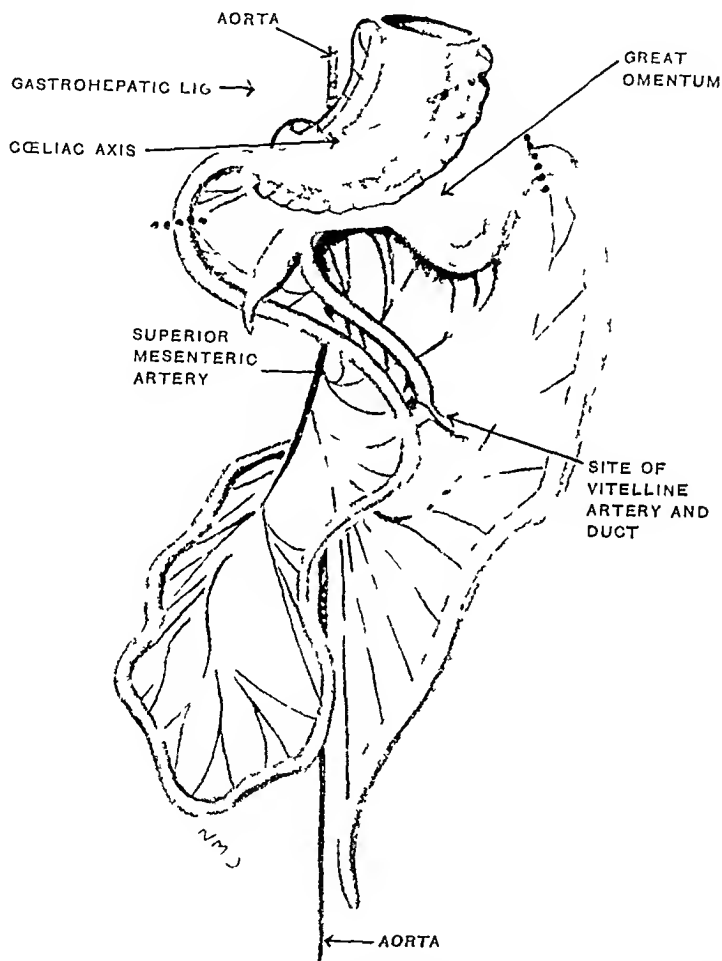


FIG. 176.—Mal rotation of midgut loop. Reversed rotation of the prearterial segment through 90° in a clockwise direction. Arrested rotation of the postarterial segment. The mesentery is folded over as on a hinge at the line of the superior mesenteric artery.

lumbar vertebræ. It may happen, as in the cases of Durante,⁸ Clement,⁹ Rixford,¹⁰ and the two I report, that no secondary adhesion whatever takes place. In this event, the whole midgut loop, the entire small intestine (except upper duodenum) and proximal half of the colon, remain suspended by an extremely narrow pedicle—the duodeno-colic isthmus of the embryo (*see Fig. 180*).

It appears most likely that the colon and cæcum return first through a lax umbilical ring, carrying with them the lower end of the ileum and superior mesenteric artery. The small intestine immediately following on will not tend to pass behind the artery since the latter is not now held forwards to the umbilicus, but rather to displace it and the large intestine to the left.

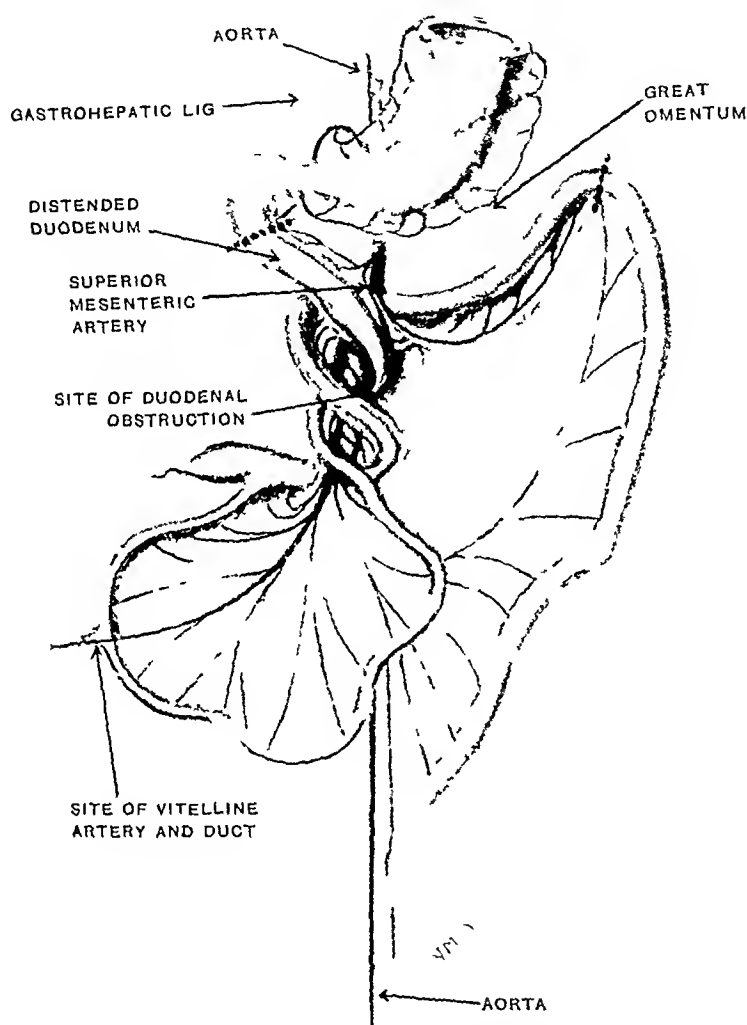


FIG. 177.—Volvulus of midgut loop superimposed on non-rotation. The twist involves one and a quarter turns—450°—in a clockwise direction from the original sagittal plane. That is, it deviates by two complete turns from the normal fully developed position. Note that the cæcum has attained its normal location. (Case 2)

The following authors record cases of non-rotation: Armstrong¹¹, Berry,¹² Blake,¹³ Cribot,¹⁴ Cheine,¹⁵ Clement,⁹ Colette,¹⁶ Delatou,¹⁷ (2 cases), Descomps,¹⁸ Downes,¹⁹ Fagge,²⁰ Farabauf,¹ Huntington,²¹ (4 cases), Huist,²² (2 cases), Klopp,²³ Malcolm,²⁴ Mivo,²⁵ (5 cases), John Reid,²⁶ (2 cases), D. G. Reid,²⁷ Rixford,¹⁰ (3 cases), Schiupp,²⁸ Simpson,²⁹ Stungis,³⁰ Le Wald,³¹ (2 cases), Young.¹²

Group 2 REVERSED ROTATION OF THE MIDGUT LOOP—This is a rare condition in which a rotation through 90° takes place in a clockwise direction so that the transverse colon is brought to cross behind the mesenteric artery close to its origin, and the duodenum crosses the vessel at the same point anteriorly. The intestines, apart from these anomalies, occupy their proper positions, but of course their anterior and posterior surfaces are reversed (*Figs 175, 179*)

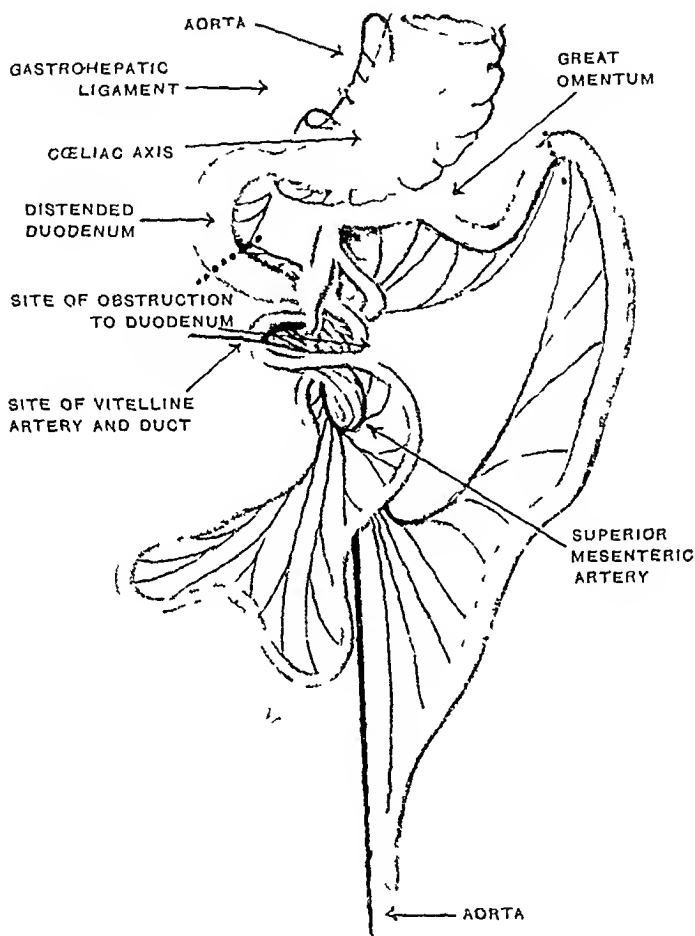


FIG. 178.—Volvulus of the entire small intestine (excepting duodenum) superimposed on mid rotation as shown in *Fig 176*. The twist involves one complete turn of the parts imperturbed from the original sagittal plane in a clockwise direction (*Case 3*)

Of this condition I have but two cases to cite that of Hunter,⁷ and one of those I report (*Case 1*). In both of these the mesentery had acquired its usual oblique attachment down to the right iliac fossa but the ascending colon and caecum retained a free mesentery, having failed to adhere completely to the posterior abdominal wall. By the adhesion of the mesentery below, the transverse colon was trapped where it passed under the origin of the mesentery

vessels, and in Case 1 (*vide infra*) a narrow but clear tunnel was left for its passage at this site (*see Fig 179*)

It is clear that the cæcum and colon must have been reduced first from the umbilical cord, probably carrying less ileum with them than in the previous group. The mesenteric vessels, still being held forwards to some extent by their connections with the unreduced pre-arterial segment, permit the cæcum and proximal colon to pass upwards and to the right behind them.

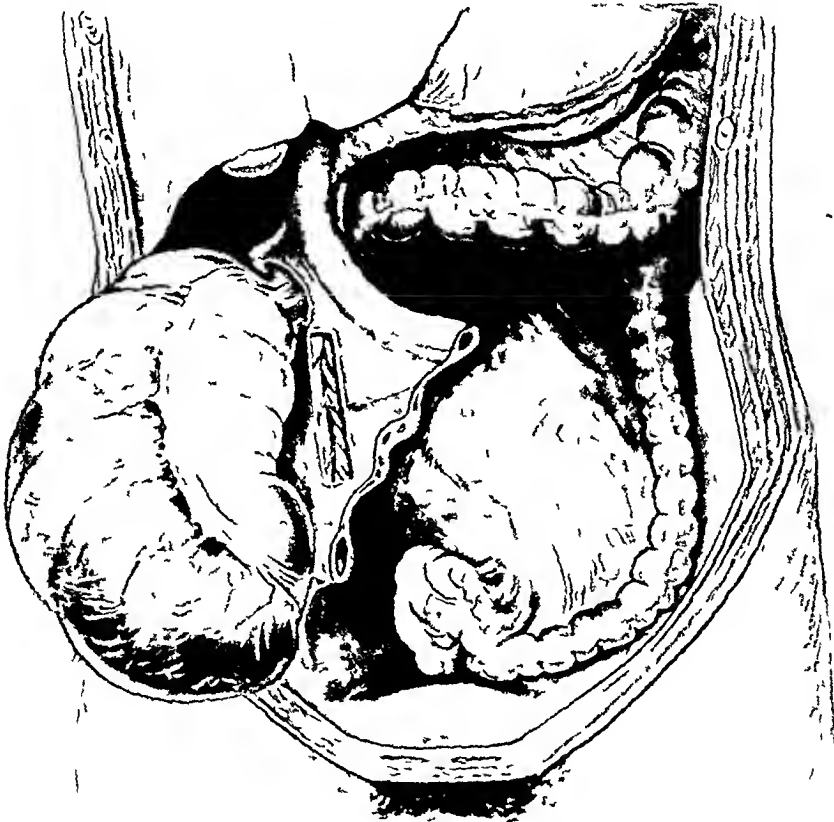


FIG 179. Case 1. Drawing made from a sketch by the author at the time of operation. Reversed rotation of midgut loop through 90° in a clockwise direction. The transverse colon is seen to cross behind the superior mesenteric vessel. The duodenum crosses in front of them. Otherwise the disposition of the viscera appears to be normal. The root of the mesentery of the small intestine (pre-arterial) has acquired its usual secondary attachment to the posterior abdominal wall, except where it crosses the transverse colon. At this point a narrow tunnel has been left for the passage of that viscus. There is a certain degree of mobile cæcum torsion of which occasioned the linking and occlusion of the large bowel where it entered the tunnel. Note the enormously distended cæcum which has ruptured its peritoneal coat.

Group 3. MAL-ROTATION OF THE MIDGUT LOOP.—By this term I intend to imply irregular defects of rotation. In some cases (*Fig 177*) the pre-arterial segment—the small intestine—passes in front of the vessels as in reversed rotation. The post-arterial segment—cæcum—also passes in front of the origin of the utery, at which point its further progress to the right has been

arrested by opposition of the misplaced small intestine. The cæcum thus comes to be retained in the subpyloric region.

The cæcum having failed to descend to the right iliac region and the main trunk of the mesenteric artery remaining turned up on itself, the mesentery does not become adherent to the posterior abdominal wall. The whole of the small intestine, from the middle of the duodenum to the termination of the ileum, remains suspended by the narrow pedicle formed by the mesenteric vessels, the duodenum, and terminal ileum, the last two lying side by side close in front of the vessels (*see Fig 178*).

In other cases the pre-arterial segment has remained entirely on the right side of the artery, as in non-rotation, or only the first few coils have penetrated behind it, the post-arterial segment has rotated normally, but has been prevented from reaching the posterior abdominal wall in the right iliac region by the unrotated small intestine. The normal fixation of the post-arterial segment on the right side of the abdomen is in this way prevented, and the cæcum and ascending colon retain then complete primitive mesentery.

In these cases the segment of bowel carrying the termination of the mesenteric artery—the lower coil of the ileum—was probably reduced first. The artery early acquiring a position at the back of the abdomen, the viscera subsequently reduced must occupy a plane anterior to it. The exact timing of the return of these viscera will determine their relative disposition.

The following authors record cases of mal-rotation: Barnard³³ Dezner,³⁴ Eggers,³⁵ Lickley and Cameron,³⁶ Telfer.³⁷

I believe that variation in size of the embryonic umbilical orifice is by far the most probable cause of these gross anomalies of the second stage of intestinal rotation.

C Derangements of the Third Stage of Rotation—Unduly early fixation of the cæcum, or failure in elongation of the colon, causes the various degrees of undescended cæcum—the subhepatic and right lumbar positions. Deficient fixation or excessive elongation of the colon accounts for the over-descended cæcum—the pelvic position. Deficient fixation of the post-arterial mesentery accounts for the various degrees of ‘mobile proximal colon’, from the sagging cæcum to the ‘floating ileocolic segment’, which has been found turned up under the spleen (Du Sejour³⁸ Voeglein³⁹).

THE PATHOLOGICAL CONSEQUENCES OF ANOMALIES OF ROTATION

Second Stage—Abnormal disposition of the intestines implies, as shown above, then abnormal attachment and fixation. The abnormal attachments may give rise to no disturbance of function. On the other hand undue fixation may cause interference with motility, kinks, and compression of the bowel. Lack of efficient fixation predisposes to ptosis, torsion and volvulus. Of the cases of anomalies of the second stage of rotation which I have collected from the literature, and including the three cases I report below—a total of 48,—35 were accidentally discovered, and the intestinal misplacement apparently gave rise to no symptoms, in 13 cases erroneous fixation of the bowels was the directly predisposing cause of intestinal obstruction. Since so large a proportion of recorded cases have been accidentally discovered, in contrast

to those giving rise to symptoms which prompted examination, it is reasonable to conclude that the numbers of symptomless cases must in reality have a much higher relative incidence. Nevertheless it is also clear that the subject of abnormal intestinal rotation is much more liable to intestinal obstruction from anatomical causes than is the individual whose intestine has attained its proper position.

The sex incidence is about three males to one female.

It is of interest to note the occurrence of symptoms relative to age. Of 13 cases, symptoms developed within a few days of birth in 6, at the age of seventeen years in 1, during adult life in 5, and in old age in 1. It is seen that a relatively high incidence is confined to a very limited period—the first few days of post-natal life. I have reason to believe that this cause of intestinal obstruction in the newly born is not widely recognized, and that its occurrence may be more frequent than is generally supposed.

Of the 13 cases in which obstructive symptoms were present, in 11 insufficient fixation of the intestines, leading to volvulus, was responsible, in 1 undue twist caused obstruction, in 1 the cause of symptoms was not determined beyond the existence of non-rotation. Volvulus due to imperfect intestinal fixation is by far the most frequent lesion. The predisposing causes of volvulus are (1) An unduly narrow base to the loop or group of loops of intestine, (2) Undue length of the mesentery, (3) A point of adhesion at the convexity of the loop, which can act as an axis of rotation. The exciting causes are (1) Unusual effort or accidental movement of the body, (2) The peristaltic motility of the intestine, (3) Undue distention of the intestine. A consideration of these causes elucidates the relative frequency of volvulus in the new-born who are the subjects of anomalies of intestinal rotation*. A predisposing cause undue narrowness of the attachment of the mesentery, is present at birth. After birth the child moves about more freely, and, as feeding is begun intestinal motility increases, thus exciting causes are superimposed immediately after birth. In the 5 cases with volvulus at this age the twist included a very extensive segment of intestine—the whole midgut loop in 4 cases (Duante⁸ Clement,⁹ Rixford¹⁰ Case 2 (Figs 177, 180), and the entire small intestine in Case 3 (Figs 178, 181)—*vide infra*. In all these cases acute duodenal obstruction was present.

Of the 6 cases in later life where volvulus was the cause of symptoms, the ileocolic segment was implicated on 5 occasions. In these cases the congenital failure of fixation of the proximal colon (post-arterial segment) was the predisposing cause. Distention of the cæcum was most probably the exciting cause in 4 of them while the withdrawal of abdominal packs after

* The occurrence of volvulus during intra-uterine life has been recorded by Cripps,⁴⁰ Pitt,⁴¹ Gessner,⁴² Resmelli,⁴³ and Maxwell.⁴⁴ I have reviewed their papers, but am unable to determine with certainty from the anatomical details given, whether any anomaly of intestinal rotation was present or not. Resmelli's illustration is suggestive of involvement of the whole midgut loop in a volvulus. The severe degree of vascular obstruction which Cripps, Pitt and Maxwell describe, and the limited extent of the volvulus in their specimens, do not correspond with the type met with in neonatal cases. The mesentery must have been anatomically imperfect in its formation to permit the occurrence of volvulus, but, with the possible exception of Resmelli's case, I do not think any gross error of intestinal rotation is likely to have been present.

a pelvic operation produced the twist artificially in 1 case (Rivford¹⁰) in the sixth individual in whom volvulus was present, the greater part of the small intestine was implicated in a twist of long standing, which only gave rise to symptoms by causing the impaction of a gall-stone in the partially compressed jejunum (Bainard³³)

The single case of undue fixation of the intestine was one of mal rotation in a new-born infant, the upper end of the jejunum was obstructed by

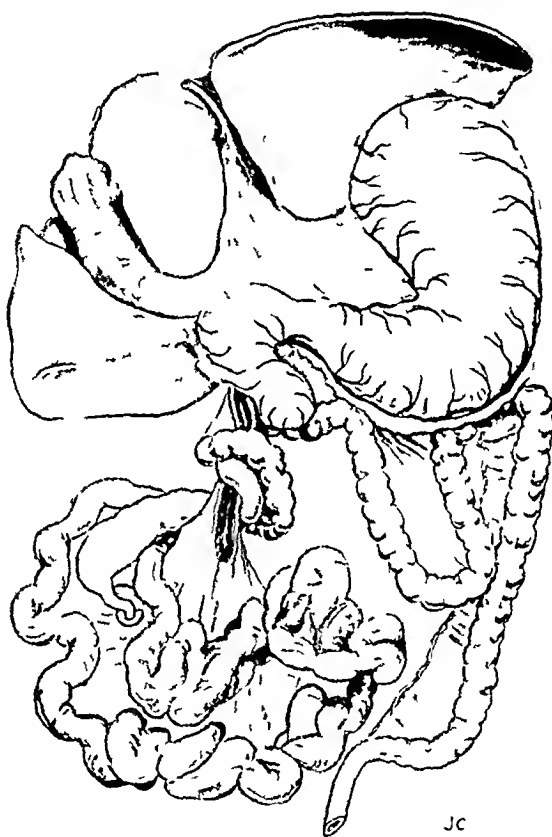


FIG 180.—Case 2 Drawing from the post mortem specimen. Note the duodenum and gall bladder distended with bile the site of obstruction of the duodenum where it enters the neck of the volvulus the tightness with which the duodenum is wound about the mesenteric pedicle on account of the fixity of its first and second parts. The comparatively wide spiral which the colon describes has occasioned no obstruction. Note the large free mass of the volvulus and its narrow pedicle. The peculiar form of the transverse colon is typical of the condition of non rotation of the gut. (See diagram Fig 177)

extensive adhesions and by compression between the misplaced ileum and ascending colon (Denzei³⁴)

The case in which the cause of mild obstructive symptoms was not accurately determined was one in which non-rotation was recognized radiologically, but in which operation was not indicated (Huist²²)

From these data it appears that failure of efficient intestinal fixation and secondary volvulus is the characteristic pathological consequence of

anomalous intestinal rotation Further, that volvulus from this cause has its highest incidence within a few days of birth, and that at this time a very extensive volvulus is characteristic Volvulus of the ileocaecal segment is the typical lesion in later life

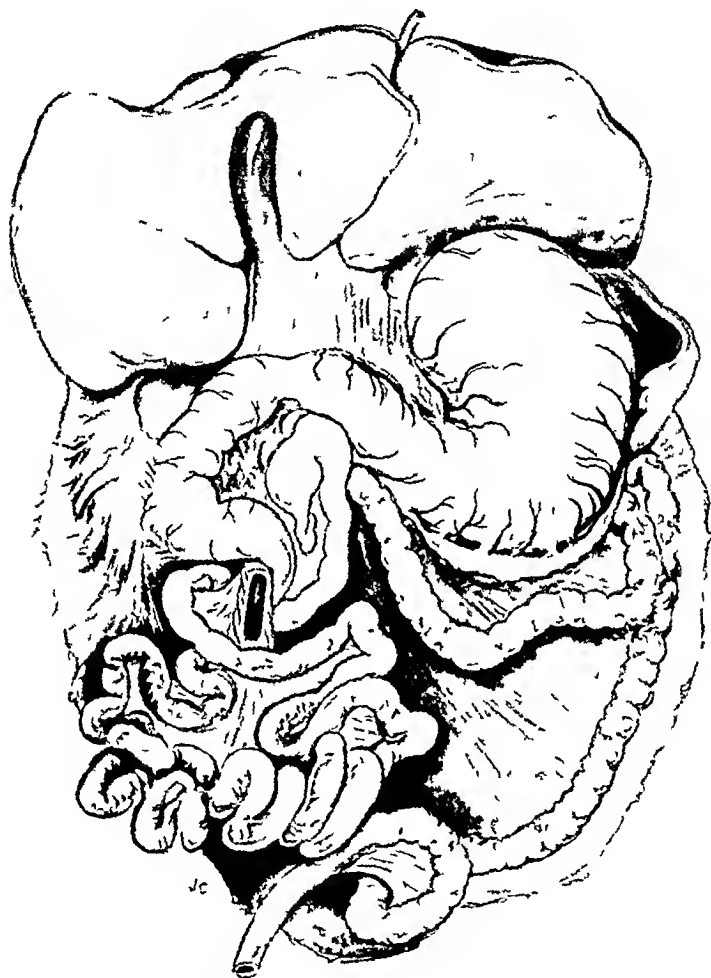


FIG. 181.—Case 3 Drawing from the post mortem specimen There is a volvulus of the entire small intestine Note the duodenum distended with bile the site of the obstruction of the duodenum where it enters the neck of the volvulus the tightness with which the duodenum is wound about the mesenteric pedicle on account of the fixation of its first and second parts The comparatively wide spiral which the ileum describes around the pedicle occasions no obstruction Note the large free mass of the volvulus and the narrowness of its pedicle The caecum is seen to occupy the subpyloric position typical of mal rotation (See diagram FIG. 178)

Third Stage—In this connection one has but to mention the important contribution by Waugh⁴⁵ on 'The morbid consequences of a mobile ascending colon' and the records of Jones⁴⁶ Treves⁴⁷ Anceel and Cavaillon⁴⁸ Voeglein⁴⁹ Du Sejour⁵⁰ and many others of torsion and volvulus affecting the inefficiently fixed ileocaecal segment

REPORT OF THREE CASES IN WHICH ANOMALOUS INTESTINAL ROTATION LED TO VOLVULUS WITH ACUTE INTESTINAL OBSTRUCTION

For permission to make use of the first case I am indebted to Mr James M Graham, whom I had the privilege to assist at the operation, on March 15, 1919

Case 1—Reversed rotation of the midgut loop deficient fixation, volvulus of the cæcum and ascending colon

The patient was a spare old man of 68 years, obviously suffering from acute intestinal obstruction. His previous history recorded a similar attack, which had occurred about ten years before. From it he had recovered spontaneously. From that time until three days before we saw him he had enjoyed excellent health.

Three days before examination he had been seized with an acute cramp like pain in the lower abdomen while out in his fields. The pain caused him to vomit and feel faint, and he took to his bed. The abdominal pain remained fairly continuous and severe, colicky exacerbations recurred at frequent intervals. The vomiting, at first of gastric contents and infrequent, partook later of the regurgitant type and became more frequent. Abdominal distention was noted. There had been complete constipation from the onset of the attack.

On examination, the abdomen was found to be considerably distended all over. The outline of a large and distinct swelling was visible, crossing the mid-line from the upper right to the lower left quadrant. The abdomen was moderately tense and tympanic all over. The visible swelling was tense, elastic, and tympanic. It was fixed above and to the right, and could be rocked from side to side below. There was little tenderness, and no evidence of peritoneal infection. External examination revealed no indication of the cause or exact site of the obstruction. The patient's condition on the third day of complete obstruction was indicative of an occlusion of the large bowel, and the visible tumour was recognized as the ballooned cæcum.

OPERATION—Immediate operation was undertaken. The abdomen was opened by a right paramedian incision. The enormously distended cæcum at once presented. It was very tense, darkly engorged, and the peritoneal coat had ruptured over its convexity, it seemed about to burst. It was punctured with a hollow needle and gas allowed to escape, this rendered it capable of delivery. We found that the ascending colon and cæcum were possessed of a considerable free mesentery, and had undergone a torsion on their own longitudinal axis of about 180° in a clockwise direction. The gut was so injured by extreme distention, the greater part of its surface being devoid of peritoneum and showing gangrenous patches, that it was thought immediate resection offered the only prospect of recovery. The small intestine was distended and congested. On attempting to define healthy gut beyond the site of volvulus, the colon was found to dive into a tunnel at the back of the abdomen. Further examination demonstrated that the colon, from the hepatic flexure, took a course along the posterior abdominal wall under the mesenteric vessels near their origin (see Fig 179). The transverse colon turned forwards from this position, under cover of the stomach, and occupied its usual site in the left half. The tunnel through which the large intestine passed was just wide enough to accommodate it comfortably, it was a clean-cut passage with smooth firm walls. The small intestine lay anterior to the colon and the mesenteric vessels. We recognized the condition as some form of developmental malposition. The practical indications were clear. The ileum was divided near the cæcum, and its upper end closed by inversion. The colon was divided on the left side of the tunnel, and its distal segment closed by inversion. The stump of the colon could then be pushed through to the right out of the tunnel, leaving it empty and the colon free. The cæcum and ascending colon were then removed after their mesentery had been secured. Alimentary continuity was re-established by a lateral anastomosis between the lower end of the ileum and the transverse colon. The abdomen was closed.

The operation was particularly difficult on account of the distended intestines, the very unusual anomaly, and the circumstances in which it was conducted. The patient's condition was, however, fairly good at its termination. He succumbed three days later.

No post-mortem examination was made.

I made a sketch of the conditions found at operation at that time and the literature was consulted but no record of a similar case could be found. We remained uncertain as to the embryological significance of the condition, until its true nature was more clearly defined by the study of the specimen from *Case 2*. A further search of the literature then brought Hunter's case⁷ of reversed rotation to my notice which confirmed me in my opinions both as to the anatomy and causation of the condition.

Fig 179 is a drawing from the original sketch made at the time of operation. Note how the colon dives back behind the origin of the mesenteric artery while the duodenum passes in front. The well-defined orifice of the tunnel for the colon is shown. I would especially emphasize the fact that the general disposition of the viscera appears quite normal.

It is clear that a reversed (clockwise) rotation of the mid-gut loop through 90° had occurred at the second stage of embryonic intestinal rotation causing the colon to pass behind and the duodenum in front of, the mesenteric vessels at their origin. During the third stage the normal adhesion of the mesentery had proceeded down towards the right iliac region, trapping the transverse colon in a tunnel between its original root and the secondarily acquired attachment below. As is so common in cases of perverted rotation the secondary adhesion of the mesentery had remained incomplete leaving the cecum and ascending colon free. Late in life, probably on account of a temporary cecal distention volvulus occurred and was aggravated in its effects by the fixation of the transverse colon in the retro-arterial tunnel.

Cases 2 and 3 occurred in the practice of the Simpson Memorial Maternity Hospital, Edinburgh. I am indebted to Dr J. A. Douglas, lately Resident Surgeon to that hospital for notes of their histories. I am indebted to Mr John Fraser to whose charge the cases were transferred at the Royal Hospital for Sick Children for notes of their treatment and for the specimens from which *Figs 180 and 181* were drawn.

Case 2—Non rotation deficient fixation volvulus of the entire midgut loop

Baby J. W. male born on Feb. 6, 1923 after a difficult labour and forceps delivery. He appeared to be a normal healthy baby. Meconium was passed as usual. He was put to the breast, and took his feeds well. The stools were quite normal.

On the fifth day he began to vomit after feeds. Albumen-water and whey were substituted for breast feeding but were similarly rejected. The vomit early acquired a green colour from admixture of bile. This continued for five days, during which the stools are said to have been normal. On the fifth day of illness a small quantity of blood was seen in the stool. No abdominal distention had been noted. The baby had lost weight. On this day Feb. 16 he was transmitted to the Royal Hospital for Sick Children.

On admission to the Children's Hospital he was but slightly emaciated, the bowels moved shortly after admission. There was no abdominal distention.

On the sixth day of illness, in spite of careful dieting, vomiting of bile-stained stomach contents continued. It may be worthy of note that regurgitation took place twenty minutes after each feed with regularity.

On the seventh day of illness, emaciation and dehydration were more marked. Vomiting had continued as before. There had been one very small motion. Gastric peristalsis was observed. On these indications, laparotomy was undertaken by Mr Fraser.

OPERATION, Feb. 18—The abdomen was opened by a right paramedian incision through the upper half of the rectus muscle. The distended stomach and upper part of the duodenum presented in the wound. The pylorus was widely dilated, forming but a slight constriction between the dilated viscera on either side. The small intestine was found collapsed but moderately engorged with blood. The transverse colon was identified with difficulty, being unusually deeply situated. The site of obstruction was obviously at the lower part of the duodenum, and it was recognized that some developmental anomaly in disposition of the intestines was responsible. The conditions of the operation did not permit further investigation at the time. The outstanding feature was acute duodenal obstruction, and this condition was relieved by a gastrojejunostomy. The duodenojejunal flexure could not be found, but one of the highest loops of jejunum was selected, approximated to the stomach by the anterior route and anastomosis carried out. The abdomen was closed.

The child did not rally from his weak and emaciated condition, and died twelve hours later.

REPORT ON SPECIMEN (Fig. 180)—The abdominal viscera were fixed *in situ* by formalin injection. At post-mortem examination they were removed entire by stripping them from the posterior abdominal wall.

The anastomosis was in perfect condition, it was undone in order to obtain a clearer view of the viscera.

The liver was normal. The gall-bladder and bile-duets were considerably distended. The stomach was anatomically normal, but considerably distended. The pylorus was dilated. The great omentum was ill developed and very short. It was adherent as usual to the transverse colon and mesocolon in their left half, but not to their misplaced right half. The upper part of the duodenum was enormously distended by darkly bile-stained fluid. The first part was normal in its relations and fixation. The second part passed downwards, obliquely from right to left, being dragged towards the middle line at its lower end by its implication in the volvulus. It was attached posteriorly over the right renal vessels, internal to the kidney. Its lower end crossed the mesenteric vessels anteriorly, and, entering the volvulus, spiralled completely round them in a clockwise direction. The site of obstruction was at the point where the duodenum turned sharply round the vessels.

The pancreas was normally disposed, with the exception of the uncinate process (of Winslow). This process formed a little tongue in the mesoduodenum which was attached to the lower part of the duodenal loop, and was drawn across by it in front of the mesenteric vessels. Its extremity entered the volvulus with the duodenum.

The rectum, pelvic colon, descending colon, and splenic flexure were quite normal, and practically empty.

The transverse colon described a narrow U-shaped loop, one limb was attached to the splenic flexure, the other ended below the pylorus, where the colon entered the neck of the volvulus by passing behind the superior mesenteric vessels and spiralling round them. The transverse mesocolon was of normal length, permitting considerable freedom of movement to the loop.

The superior mesenteric artery was normal in origin and was properly distributed, although its relations were disturbed (*vide infra*).

The volvulus implicated the whole of the intestines of the original midgut loop. It involved the entire mass of the small intestine from the second part of the duodenum downwards, the cecum, ascending colon, and the right half of the transverse colon. It consisted of one and one-quarter turns (450°) in a clockwise direction of the mass of gut mentioned above. The mass was suspended by its narrow pedicle alone, and

was otherwise quite free from fixation. The pedicle corresponding to the duodeno-colic isthmus of the embryo, was about 1 cm. in thickness and consisted of the superior mesenteric vessels, the extremities of the midgut segment and their narrow mesenteries, all twisted together. The duodenum being fixed at its second part, and tightly wound round the vessels was occluded by kinking. The colon being free in its transverse part, was less tightly wound and described an open spiral round the vessels which occasioned no obstruction. There was a moderate degree of engorgement of the mesenteric veins, and the intestine of the volvulus showed slight congestion, but nothing approaching strangulation. On examining the isolated mass of intestines, the cæcum was identified on its right and posterior aspect—it had reached its normal site by a devious route, one and a quarter reversed turns. The mesentery formed the central column of the mass, and round it the intestinal coils were clustered.

The twist could be reduced easily by rotating the whole mass of intestines through one and one quarter turns in an anti-clockwise direction. By this manoeuvre the typical conditions of non-rotation were reproduced. The colon was left-sided and the duodenum, passing down the right side of the mesenteric pedicle, was completely relieved from compression, so that fluid could be propelled through it readily. The lower part of the duodenum was found to be possessed of a short free mesentery.

On rotating the mass further in an anti-clockwise direction through 270° , the normal disposition of the intestines was attained. The duodenum and uncinate process of the pancreas were drawn into their proper position, behind the origin of the mesenteric vessels, and the former took up this position quite naturally, without any kink or compression. The transverse colon was drawn across the origin of the mesenteric vessels anteriorly, and the ascending colon and cæcum came to occupy the right lumbar and iliac regions. The mesentery was so spread out that, had the cæcum attained this position during life, there appears no reason why the mesentery should not have acquired its normal secondary adhesion and wide root.

From the above facts I conclude that the intestine was in a state of non-rotation at birth, and that, on account of deficient stabilization by secondary adhesion of the mesentery, the midgut mass had undergone a volvulus on its narrow pedicle on the fifth day of post-natal life. The volvulus had probably increased its torsion gradually, inducing a progressive degree of duodenal obstruction, which became complete on the seventh day of illness.

Case 3—Mal rotation, deficient fixation, volvulus of the entire small intestine

Baby E. A. W., female, born on Feb. 22, 1923, after a normal labour. The child appeared to be healthy and in every way normal. She was put to the breast and took her feeds well. On the third day of life she began to vomit her feeds. The vomit soon acquired a dark-green colour from the presence of bile. Meconium was passed immediately after birth, and subsequent motions retained the characters of meconium, failing to acquire the normal yellow colour. A rectal lavage, administered on the third day of illness, was returned but slightly stained by meconium. On this day, Feb. 28, she was transferred to the Sick Children's Hospital.

On admission, examination showed that emaciation and dehydration had already proceeded to a very grave degree. The abdomen was considerably distended in its upper part. Gastric peristalsis was easily elicited. Rectal examination demonstrated that a trace of meconium was still present. Shortly after admission she vomited material dark from the presence of altered blood as well as bile. On these indications Mr. Fraser undertook immediate laparotomy.

OPERATION, Feb. 28.—The abdomen was opened by a right paramedian incision through the upper half of the rectus muscle. The tensely distended stomach presented, and examination revealed a widely dilated pylorus and the upper part of the duodenum also distended. These viscera were deeply congested. The small intestine was collapsed, but engorged with blood. The transverse colon could not be identified. The cæcum and appendix lay just below the pylorus. As in the previous case, acute duodenal obstruction, dependent on a developmental malposition of the intestines, was recognized. The duodenal-jejunal flexure could not be

identified, but a loop of intestine was brought up by the anterior route and a short-circuiting anastomosis carried out. The abdomen was closed.

The child, almost beyond hope of recovery before operation, died seven hours later.

REPORT ON SPECIMEN (Fig 181)—The abdominal viscera were fixed *in situ* by formalin injection, and removed *en masse* at the post-mortem examination.

The anastomosis was undone in order to obtain a clear view of the viscera. The liver, gall-bladder and bile-duets were normal. The stomach and first and second parts of the duodenum were normally situated and attached. They were greatly distended forming a single cavity, which the dilated pylorus encroached upon as a shallow constriction. They were deeply congested, and blood was extensively extravasated into their walls. The great omentum was normal, and was adherent to the anterior surfaces of the transverse colon and mesocolon.

The third part of the duodenum was the site of obstruction. It turned from the second part which was attached over the right kidney just below its hilum, abruptly forwards downwards, and to the left, to pass anterior to the mesenteric vessels. From this point it spiralled closely round the mesenteric vessels in a clockwise direction. Its second part being fixed, the duodenum was wound very tightly round the vessels, and was in this way kinked and occluded.

The pancreas was normally situated, except that the uncinate process followed the third part of the duodenum in front of the mesenteric vessels.

The rectum, pelvic and descending colons, and splenic flexure were normal and empty.

The transverse colon was folded into a W-shaped loop, one end attached to the splenic flexure, the other terminating under cover of the pyloric end of the stomach. The transverse mesocolon was very short, so that the intestine was tucked up behind the stomach.

The segment of bowel corresponding to the ascending colon was coiled upon itself in the concavity of the duodenal loop, lying over the head of the pancreas. From it the caecum projected forwards, its convex surface presenting while the ileum and appendix were attached to its deep surface. The ileum passed from the caecum behind the mesenteric vessels, and so entered the neck of the volvulus.

The superior mesenteric artery was normal in origin and in distribution, its relations are considered below.

The volvulus implicated the whole of the small intestine with the exception of the first and second parts of the duodenum. It consisted of one complete turn, in a clockwise direction, of the entire mass of small intestine. The mass was suspended on its narrow twisted pedicle alone, and was otherwise free from fixation. The pedicle, about 1 cm in thickness, consisted of the superior mesenteric vessels and the closely approximated and parallel duodenum and terminal ileum, the two latter spiralling round the former. The ileum, not being fixed by the mobile caecum, was wound round the vessels less tightly than was the duodenum, and, taking a wider spiral course, was not obstructed. The veins of the mesentery in the volvulus were engorged with blood, and the intestine showed considerable congestion. The mass of intestine was disposed around the central mesenteric column, as in the previous specimen.

Again I found the twist could be easily reduced to a condition resembling non-rotation by one anti-clockwise turn of the mass, the caecum, however, still maintained its position below the pylorus. On carrying out a further rotation of the mass in an anti-clockwise direction, through 270°, normal conditions were established, as described in Case 2, with the exception that the caecum could be brought only so far as the right loin, as the colon was unduly short. Reduction of the volvulus entirely relieved the duodenal constriction.

From the above examination, I conclude that the intestines were in a condition of mal-rotation at the time of birth, the duodenum lying in front of the mesenteric pedicle, and the caecum, arrested by the former, in the subpyloric position. The caecum having failed to reach the right iliac region and so spread out the mesentery, no secondary adhesion of the latter had taken place, and the mass of small intestines

remained suspended by its original narrow pedicle. On the third day of life the mass had undergone volvulus. In this case the duodenal obstruction appears to have been complete from the onset of volvulus. The vascular obstruction was also more severe than in the previous case, but not so complete as to threaten the vitality of the intestine.

ABSTRACT OF PARALLEL CASES FROM THE LITERATURE

I have noted no case similar to *Case 1*. Volvulus of the ileocecal segment in cases of anomalies of the third stage of rotation with simple deficiency of mesenteric fixation, are fairly common but the retro-arterial position of the colon, signifying reversed rotation is apparently very rare. In Hunter's⁷ case of reversed rotation, the anomaly had no clinical significance, in it a mesenteric cyst caused intestinal obstruction in a new-born child.

Three records of cases of volvulus neonatorum associated with anomalous rotation of the midgut loop have come to my notice and it may be of interest to recapitulate them briefly.

Durante,⁸ in a paper on "Occlusions congénitales de l'Intestin" gives an interesting account of a case of volvulus in a child a few days old, which one recognizes as a torsion of the entire midgut loop, as in *Case 2*.

The child was admitted to hospital within a few days of birth. There were vomiting, hæmatemesis, and melæna. Death occurred on the third day of illness.

Post-mortem examination demonstrated the presence of an extensive volvulus. The volvulus hung on a pedicle, suspended from the point where the duodenum crossed the transverse colon. There was a clockwise twist of one and one-half turns, so that the cæcum was situated on the left side of the mass of intestines. The duodenum, to the point where it entered the neck of the volvulus, was notably distended. The site of obstruction was at the point where the duodenum was twisted round the pedicle.

From these facts, there can be little doubt that the case was a counterpart of *Case 2*—non-rotation, with secondary volvulus of the entire midgut loop and acute duodenal obstruction shortly after birth.

Clement⁹ describes a similar case under the title "Volvulus de l'Intestin grêle, avec Sténose secondaire du Gros Intestin, chez un Nouveau-né."

The child was two weeks premature, but otherwise apparently normal. It passed meconium, and took its feeds, it did not vomit. On the second night it was found in its cradle looking very pale, and the temperature was 35° C. The abdomen became very distended and tense, and the subcutaneous veins of the abdominal wall became dilated. (There is no note as to vomiting at this time.) It died in collapse during the second day of illness.

Post-mortem examination showed that the small intestine was drawn together into a congested mass. The mass was supported by a narrow, twisted pedicle at the origin of the superior mesenteric artery. There were two complete spiral turns in a clockwise direction. The transverse colon crossed behind the mesenteric vessels, where it was compressed. (I think this point need not be stressed, as the bowel above was not distended.)

The author fails to recognize the significance of the retro-arterial position of the transverse colon, for he says that there was a volvulus, "but not a volvulus of the entire vitelline loop, for in spite of two spiral turns, the large intestine was in its place." His illustration of the specimen is the counterpart

of Fig 180, and I think there is no doubt that the entire midgut loop was involved in the twist, and that the retro-arterial position of the colon represents its implication in the volvulus. It is not possible to determine from the facts given whether the condition, at birth, was one of non-rotation or reversed rotation. The case is of interest as representing acute intestinal strangulation as the outstanding feature in contrast to the greater prominence of obstructive signs in the other cases of this class.

Rixford¹⁰ describes a case of great interest, both from the embryological and symptomatic standpoints, and from the operative treatment, which he applied with complete success.

The patient was a boy of 5 years, who had suffered from chronic intestinal obstruction since the first few days of infancy. There were recurrent attacks of colicky pain and vomiting (presence or absence of bile in vomit is not mentioned). These attacks followed immediately after meals, and were very frequent. They were relieved by abstaining from food. He had never been able to take a normal full meal at any time. There was a severe degree of emaciation, due to partial starvation. The abdomen was distended in its upper part and concave below.

A chronic high intestinal obstruction was diagnosed and laparotomy undertaken. The obstruction was found to be due to an extensive chronic volvulus of the intestines. Included in the volvulus were the entire small intestine from below the biliary papilla, the ascending, and part of the transverse colon. Only the stomach, pylorus, and upper duodenum were distended; the remainder of the intestines were collapsed and atrophic. The site of obstruction was at the duodenum, just below the biliary papilla. The entire mass of intestines, having no other point of attachment than the twisted pedicle, which consisted of a cord hardly more than an inch in diameter, was lifted bodily out of the abdomen. The mass could then be twisted about freely in any direction. On untwisting the volvulus in an anti-clockwise direction through one complete turn, adhesions came into view, which bound the duodenum to the transverse colon. These bands were cut. The intestinal mass was then turned further in an anti-clockwise direction, so that the ascending colon lay to the right, the transverse colon in front of the origin of the superior mesenteric artery, the small intestine to the left, and the duodenum behind the origin of the artery. The viscera were replaced into the abdomen. The tissues assumed this normal position quite readily. The duodenal obstruction was completely relieved by this artificial construction of normal relations.

Improvement was immediate, and, in the author's words, "he grew like the blossom stalk of an aloe and is now a strapping, normal boy of 13."

SOME SPECIAL POINTS IN THE SURGICAL PATHOLOGY OF VOLVULUS NEONATORUM DUE TO ANOMALIES OF INTESTINAL ROTATION

From the point of view of surgical pathology the salient features of the condition are distinctive and peculiar. A volvulus of intestine usually implies a more or less limited segment of bowel whose extremities are occluded by the compression of the twist, and whose blood-supply is seriously embarrassed or completely interrupted by compression of its mesentery. It is at once recognized as a greatly congested and dilated portion of intestine, sharply demarcated from the bowel above and below.

Here the conditions are so entirely different as to demand special consideration. The extent of intestine implicated in the volvulus is so unusually great as to render recognition of the condition difficult. There is obstruction only at the upper extremity (duodenum) of the twisted gut, the

lower extremity (ileum or transverse colon) suffers no occlusion collapse, not dilatation of the implicated bowel takes place. The degree of vascular obstruction varies but tends to be slight. It was severe in one case (Clément), and quite absent in another (Rixford). In the remainder it was present but of mild degree causing but slight congestion of the intestines involved.

Above the site of duodenal obstruction the usual phenomena consequent on intestinal occlusion from any cause are present. The upper duodenum and stomach become dilated, as their maximum capacity is reached their content is regurgitated. In the later stages their vitality is impaired by extreme dilatation, and inflammatory reaction with extravasation of blood occurs in their walls.

I would emphasize that one is essentially dealing with acute duodenal obstruction, due to external pressure on the gut. The obstruction is caused by a volvulus from which all the characteristic features of the condition are absent.

THE DIAGNOSIS OF ANOMALIES OF INTESTINAL ROTATION

1 Clinical Diagnosis in the Presence of a Lesion Independent of the Anomaly—Inflammatory lesion of an appendix misplaced on account of anomalous rotation, is the chief consideration. It is necessary only to mention the well-recognized retrocolic and subhepatic locations of appendicitis. It is diagnosed when the circumstances and history are opposed to biliary or renal conditions, and favour appendicitis as the cause of local inflammation. It is a diagnosis of probability, and cannot be dogmatic. For example, I saw some time ago a case of leaking duodenal ulcer with localized abscess in a girl of 16 years which was provisionally diagnosed as subhepatic appendicitis. The opinion was justifiable, but proved to be incorrect. These locations of the appendix are dependent on deficiency of the third stage of intestinal rotation.

In cases of obscure inflammatory lesions of the left side of the abdomen, appendicitis with non-rotation of the intestine is to be considered—more especially in the young. In older persons it is to be differentiated from left salpingitis, from sigmoid diverticulitis, and from inflammatory complications of neoplasm. If appendicitis is thought to be the most probable cause, subsequent operation may be facilitated by gaining knowledge as to the disposition of the large intestine. Non-rotation may be recognized by the elicitation of the distinctive colonic percussion note over the greater part of the left abdomen, and its absence from the right side (Mayo²⁵). Complete transposition of the viscera is easily excluded by examination of the liver, etc.

Less easily differentiated are cases in which the 'wandering cæcum' has transgressed the middle line. The wandering cæcum (a defect of mesenteric fixation at the third stage of rotation) may lie in the left abdomen anywhere between the lower pole of the spleen and the left pelvis. In such cases a diagnosis of non-rotation would probably be made. I did so recently in a case of left pelvic appendicitis in a child. On opening the abdomen by a left iliac incision, the misplacement was found to be due to 'excessive rotation' of a mobile cæcum, which was so long that it reached the left side.

In cases where circumstances permit, and an acute inflammatory lesion does not contra-indicate it, the pre-operative diagnosis is greatly simplified and assured by X-ray examination with the bismuth enema.

The clinical diagnosis of non-rotation, while not of prime importance will aid the planning of the operation and the precision of its conduct. If the left-sided location is associated with non-rotation, the root of the appendix will be found on the right side of the cæcum. If a mobile cæcum has become folded up under the spleen or has crossed the pelvic floor to the left side the root of the appendix will be found on its upper or left surface.

2 Diagnosis at Operation—In exploratory operations of the intestines it is important that abnormal dispositions should be recognized and quickly followed at whatever point the abdomen may have been opened. In operations designed to apply to a particular portion of intestine, as in gastrojejunostomy, their recognition may be of very great consequence. For example, in operating for gastric ulcer, Armstrong¹¹ found the condition of non-rotation. He performed gastrojejunostomy. No duodenojejunal flexure could be found, but a fixed portion of intestine resembling it proved to be the ileum. Armstrong's knowledge of the characteristic features of non-rotation saved his patient from having a gastro-ileostomy performed.

On opening the abdomen in the right iliac region the large intestine cannot be found—This may be due either to failure in descent of the cæcum or non-rotation. The relations of the duodenum will at once decide the question. If the duodenum passes down the right side of the root of the mesentery and is not covered by the colon or mesocolon, the condition is that of non-rotation, the cæcum is to be sought in the left iliac or left pelvic sites. If the large intestine is found to cross the duodenum, the cæcum is to be sought in the subhepatic region or folded back towards the splenic flexure.

On opening the upper abdomen the transverse colon is not apparent—This may be due to non-rotation or to reversed rotation. The position of the duodenum will decide the question. If the duodenum, uncovered by large bowel and possessed of a free mesentery, passes down the right side of the root of the mesentery, non-rotation is present, and the ascending colon will be found to pass up the left side of the vertebral column, there is no duodenojejunal flexure, and the upper coil of jejunum is in the right hypochondriac region. If the jejunum crosses in front of the mesenteric vessels, from right to left, the condition of reversed rotation should be suspected, and the transverse colon identified behind the origin of the superior mesenteric artery, the ascending colon is in its normal place, there is no duodenojejunal flexure, and the upper coil of jejunum will be found about the mid-line, in front of the mesenteric root.

On opening the abdomen in the left iliac region a portion of large bowel is found lying parallel to the descending colon—Non-rotation should be suspected, the abnormal colon is probably the ascending colon, passing up from the left-sided cæcum on the left side of the vertebral column.

3 Diagnosis in the Presence of a Lesion Consequent on the Anomaly—In chronic intestinal obstruction due to abnormal adhesions, kinks, etc.

associated with anomalies of rotation, the abnormal disposition of the intestines will be discovered either by alteration in tympany as noted above or at the routine X-ray examination

In adults with anomaly of rotation, acute intestinal obstruction is usually due to a volvulus of the ileocaecal segment. In these circumstances I do not think a diagnosis of the anomaly would be possible, or of practical importance. The treatment of the bowel would be governed by exactly the same considerations as for any form of volvulus. In the presence of anomaly of rotation however, the conduct of operation would certainly be facilitated by familiarity with its characteristic disposition.

In infants with anomalies of rotation, extensive volvulus with acute duodenal obstruction is met with. In these cases I think a correct diagnosis is more possible than in the lesions of later life and it is of far greater importance. The child is apparently normal when born, and remains so for some days. Meconium is passed, and if the onset of the volvulus has allowed time food residue appears in the motions in due course on the third or fourth day. With the onset of volvulus there may be shock, though this was remarked in one case only. Vomiting begins early. It occurs in relation to food and represents expulsion of the contents of an over-full stomach, which has failed to empty itself via the duodenum. The vomit is soon deeply stained with bile, for the obstruction lies below the duodenal papilla. In the later stages there is hæmatemesis from gastric dilatation and erosion. Gastric peristalsis may be observed. The upper half of the abdomen becomes distended by the stomach and duodenum while the lower half becomes recessed from collapse of the intestines and from general emaciation and loss of body fluid. The degree of constipation varies with the degree of obstruction. The undue persistence of traces of meconium is significant of the onset of a high intestinal obstruction at a period before food residue had reached the colon. Mæna may or may not be evident.

The differential diagnosis is to be made from hypertrophic pyloric stenosis, the various forms of congenital atresia or stenosis of the intestines, pressure of a mesenteric cyst, and from acquired causes, strangulation by a persistent Meckel's diverticulum or vitelline artery, volvulus of a limited portion of the ileum, and intussusception.

Pyloric stenosis is distinguished by the later onset of symptoms by the absence of bile from the vomit, and by the shorter interval between feeding and vomiting. Atresia of the duodenum above the papilla is distinguished by very early vomiting—it may be of liquor amni within an hour or two of birth—and by similarity in other respects to pyloric stenosis. Congenital obstruction in the lower part of the duodenum of course most closely resembles volvulus neonatorum of anomalous rotation. If there is complete atresia, the absence of meconium from the intestine below furnishes a differential point. If there is only a partial stenosis, meconium may be present, and its evacuation is delayed. In this case the time of onset of vomiting is the only basis for distinction. It occurs as soon as sufficient food has been taken to fill the stomach and upper duodenum in the case of congenital stenosis, but it commences after the onset of acquired volvulus. Congenital atresia and stenosis lower in the intestine are distinguished by the more marked and

generalized abdominal distention, by the dissociation between the times of feeding and vomiting, and by absence of, or delay in evacuation of meconium. The congenital tumour which may cause intestinal obstruction in early infancy is the mesenteric cyst, its size definite outline and mobility should identify it.

The acquired lesions other than anomalous rotation with volvulus, which may cause intestinal obstruction at this age, all affect the lower part of the small intestine or the colon. They are differentiated by their more acute onset and lack of relationship between vomiting and feeding.

Imperforate anus and strangulated external hernia need not be considered in this relation.

TREATMENT

In the adult, the treatment of conditions dependent on anomalies of intestinal rotation chronic obstruction from adhesions and kinks, and acute obstruction from volvulus is guided by the same principles as apply to similar lesions from other causes. When intervention is necessary, the details of operative procedure are, of course, influenced by the anatomical conditions which are present.

In the new-born the treatment of the extensive volvulus requires special consideration. Early operative interference holds out the only hope of saving life. One has to treat acute duodenal obstruction the result of external pressure on the gut. The pressure can be relieved by reduction of the volvulus and the construction of normal conditions. Rixford has successfully done this in the exceptional case of a child who survived with partial obstruction to the age of 5 years. From the examination of the two specimens from new-born infants which I describe above, I suggest that reduction of the volvulus would be the most hopeful treatment at this age also. The intestinal mass would have to be delivered, and untwisted. One would have to decide at operation whether the duodenum were more efficiently freed of pressure or kink by leaving the reduced volvulus in the condition of non-rotation, or by carrying the mass further round to the normal position. In the two specimens examined, reduction to normal appeared to give the better result. Some form of fixation to prevent recurrence would be desirable, and I suggest that the caecum and ascending colon could be anchored in the right loin by a few points of suture to the parietal peritoneum in that region.

If on account of adhesions reduction were not feasible gastro-jejunostomy might be successful, for the blood-supply of the intestine is not threatened nor is the returning segment of the volvulus obstructed. This operation involves the regurgitation of the biliary and pancreatic secretions via the stomach, and is, moreover a more drastic procedure than reduction and fixation of the volvulus would be. It may be noted that only two records of successful operation by short-circuit for obstruction to the small intestine at this age are to be found. Einst⁴⁹ operated at the eleventh day of life for atresia of the duodenum, he performed 'duodeno-entero-anterior anastomosis', with good result. Fockens⁵⁰ operated at the eighth day of life for atresia of the ileum, he performed entero-anastomosis with success.

SUMMARY

1 The three stages of normal embryonic intestinal rotation are described. In the second stage the essential disposition of the intestines is attained.

2 Derangements of intestinal rotation are described and arranged under three heads: (i) The first stage of rotation, (ii) The second stage (subdivided into three groups, (a) non-rotation (b) reversed rotation, (c) mal-rotation) (iii) The third stage.

3 It is suggested that the cause of anomalies of the second stage is variation in size of the embryonic umbilical orifice.

4 The pathological consequences of anomalies of the second stage of intestinal rotation are described and their incidence and relative frequency are estimated from the literature. Failure of sufficient intestinal fixation and consequent volvulus is found to be the typical lesion. Volvulus from this cause has its highest incidence in the first few days of life and at this time a very extensive volvulus is characteristic. Volvulus of the ileocecal segment is the typical lesion in later life.

5 Three cases of volvulus due to anomalies of intestinal rotation are reported: (i) Reversed rotation and volvulus of the ileocecal segment in an old man, (ii) Non-rotation and volvulus of the entire midgut segment in a new-born child, (iii) Mal-rotation and volvulus of the entire small intestine in a new-born child.

6 Three similar cases from the literature are briefly quoted.

7 Some special points in the surgical pathology of extensive volvulus in infants are considered.

8 The diagnosis of anomalies of intestinal rotation is considered: (i) from the standpoint of abnormally situated appendicitis, (ii) from the point of view of recognition on the operating table, (iii) in cases of secondary volvulus, especially in the new-born.

9 An operative treatment by reduction and fixation is suggested for cases of extensive volvulus in the new-born, based upon an examination of two specimens of the condition.

APPENDIX

EXOMPHALOS AND NON-ROTATION

Since writing the above paper two cases of exomphalos have come to my notice, and the condition of the midgut loop in them is of great interest in connection with intestinal rotation, both from the embryological and surgical aspects. I am indebted to Mr John Fraser for permission to publish these cases.

Case 4—Complete exomphalos and bilateral equinovarus death.

Baby B, male, age 36 hours, was admitted on June 13, 1923, to the Royal Hospital for Sick Children, Edinburgh, under Mr John Fraser's care. The child suffered from the complete exomphalos shown in Figs 182 and 183 and a bilateral

FIG 182—*Fomphalos* Specimen from Case 4. Right lateral view. Note especially the relation of the duodenum to the superior mesenteric artery. The pylorus crosses the vessel anteriorly, and the duodenum descends from it on the right side of the artery to enter the neck of the sac in this relationship. The short mesoduodenum part of which contains the head of the pancreas is characteristic of non rotation. The manner in which the mesenteric axis is stretched out between the posterior abdominal wall and umbilical orifice is striking. The area of true sin at the neck of the sac is well seen; beyond it is the sac formed of distended umbilical cord and through its thin wall the intestinal convolutions are clearly visible. The umbilical vein is seen to pass over the cephalic surface of the sac wall to reach the stump of the cord.

1 Right kidney 2 Pylorus 3 Pancreas 4 Duodenum 5 Superior mesenteric artery 6 Hypo-ventric artery 7 Rectum 8 Umbilical orifice 9 Small intestine 10, the sac 11 Varix of true sin 12, Umbilical vein 13 Stump of cord 14 Abdominal wall 15, Iliaciform ligament

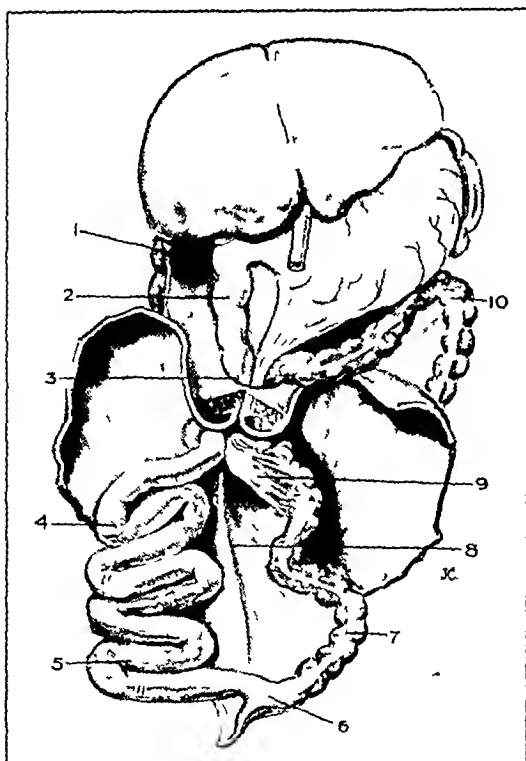
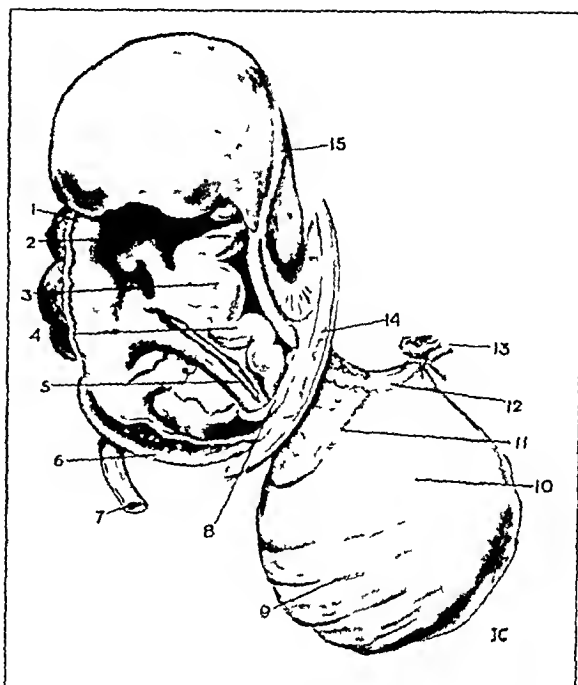


FIG 183—The same as Fig 182. Anteroposterior view, with the sac opened. The sac has been laid open in such a way as to leave only the umbilical orifice intact. The duodenum is seen to descend on the right side of the middle line and to pass into the jejunum in the right side of the sac. There is no duodenojejunal angle. The small intestine lies entirely in the right half of the sac in a convoluted mass. The splenic flexure and adjacent transverse part of colon are normal. The colon enters the sac by passing through the left side of the umbilical orifice and occupies the left part of the sac. The lower end of the ileum and caecum are seen to form the apex of the midgut loop in the sac and the mesenteric vessels are seen coursing down to this point. Note that the great omentum has become attached to the transverse colon in spite of its extra abdominal position.

1, Right kidney 2, Duodenum 3, Umbilical orifice 4, Jejunum 5, Ileum 6, Caecum 7, Ascending colon 8, Superior mesenteric vessels 9, Great omentum 10, Splenic flexure

talipes equinovarus. He was slightly premature, but otherwise normal. The sac wall was obviously infected, and already the sac contained a quantity of exudate the consequence of a commencing peritonitis. He was already so seriously toxæmic, and the protrusion was so large that operation with a view to reduction was contra-indicated. The child succumbed to toxæmia within sixteen hours of admission.

At the post-mortem the specimen shown in the figures was removed.

Case 5—Partial exomphalos, without associated deformities. operation recovery

Baby W, male, age 12 hours, was admitted on June 19 1923, to the Royal Hospital for Sick Children, Edinburgh, under the care of Mr. John Fraser. The child suffered from a partial exomphalos. There were no associated deformities, and he was in good condition. The sac, about the size of a small orange, consisted of the distended root of the umbilical cord, and the umbilical vein and arteries were obvious, coursing over its cephalic surface (*Figs 184 and 185*). The sac wall was already obviously infected. Immediate operation was undertaken by Mr. Fraser.

The neck of the protrusion was surrounded by an elliptical incision and the sac opened near this point. It contained a small quantity of inflammatory exudate with flakes of lymph and intestinal coils, deeply infected on account of a commencing peritonitis. There were dense adhesions about the neck of the sac. These were separated, and the sac was completely removed. The raw areas of adhesion of the bowel were re-peritonized. It was noted that the extruded intestine consisted of the cæcum, appendix, and lower ileal coils. These parts were in the position of non-rotation, the cæcum lying on the left side of the sac in the reversed position, the ileum occupying the right part of the sac. Reduction through the narrow umbilical orifice was not possible, and it was necessary to enlarge it by incising the linea alba above and below it. It was then found that the remainder of the small intestine occupied its normal site within the abdomen, but the proximal half of the colon was anchored over to the umbilicus and therefore was absent from its normal position. Without difficulty, rotation of the midgut loop was artificially completed, and the viscera were placed within the abdomen in their normal sites. The abdomen was closed.

The child made an uneventful recovery and left hospital thirteen days later in perfect health.

Exomphalos is the condition in which the embryonic and physiological hernia into the root of the umbilical cord has wholly or partially persisted until birth. It is clearly distinguished from true umbilical hernia by its external appearances. In contrast to the true skin which covers the former, the sac of exomphalos is, indeed, the root of the cord, much stretched out, and is recognized as a thin, translucent, gelatinous-looking membrane. The neck of the sac is surrounded by true skin, and the line of demarcation between skin and cord is clearly defined (*Fig 182*). The vessels of the cord course irregularly over the cephalic surface of the stretched sac to meet together at its apex to form the cord. The sac contains the midgut loop in whole or part. The loop is in the non-rotated condition, and the cæcum and lower end of the ileum lie at its apex. Thus, in a complete exomphalos the infant is in exactly the same condition as an embryo of the ninth week, so far as its umbilical sac is concerned. We have already expressed the view (originated by Frazer and Robbins) that the second and essential stage of rotation of the midgut loop is dependent on the reduction of the embryonic hernia and further on the sequence in which the contents are reduced. Here, in the condition of exomphalos we have proof of this hypothesis, for as

reduction has not occurred, the intestine



FIG 184—Partial omphalos. *Case 5*. Lateral view of sac. Note the sharp line of demarcation between the true skin at the neck of the sac and the distended umbilical cord which forms its walls. On the summit of the protrusion is the ligatured umbilical cord.

coils of the ileum are usually present in the of the small intestine and of the colon have been returned to the abdomen. In such a case non-rotation affects that portion of the intestine which lies within the sac and the caecum is found to be reversed—i.e., the ileum enters its right side—while the remainder has taken up a normal position. Occasionally the lowest coil of the ileum occupies the sac. These facts strongly support the view that the caecum and lower ileum are normally the last portion of the midgut loop to undergo reduction, and we may consider the condition of partial omphalos as representing an arrest of the normal process of reduction.

The recognition of these facts is of surgical importance, for in operating to repair the defect a knowledge of the disposition of the parts is essential.

The intestines are invariably adherent at the neck from long-standing constriction at this point, and frequently there are extensive adhesions to its walls, for the delicate sac becomes the site of a localized 'peritonitis' from the time of birth. Under such conditions the distinction of parts is by no means easy.

It is also of importance that, by means of this knowledge, the viscera

remains within the sac in the primitive, non-rotated condition. A further point of interest in relation to the mechanism and sequence of reduction is the fact that the caecum and lower ileum form the apex of the extruded loop occupying the middle line, at the most dependent part of the sac. The ascending colon and major portion of the transverse colon form the left limb of the loop. The convoluted small intestine forms the right limb. The two limbs pass through the umbilical orifice close together, and this point of approximation is the original embryonic duodenoecolic isthmus. In partial omphalos the caecum and lower ileum, although the greater part



FIG 185—The same as Fig 184. Anterior view. Note the ligatured umbilical cord projecting from the summit of the sac. The umbilical vessels are well seen coursing over the cephalic surface of the sac and converging on the cord. The two arteries occupy either side of the median plane while the vein lies further to the left.

can be disentangled and placed in their normal sites within the abdomen. In Case 5, Mr Fraser accomplished this with complete success freeing and rotating the extruded portion of the midgut loop and placing the caecum in the right iliac fossa.

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A CASE OF SECONDARY HYPERNEPHROMA IN THE FEMUR WITH SPONTANEOUS FRACTURE

By L R BROSTER, LONDON

Mrs E T, age 72, was admitted to the Charing Cross Hospital under Mr H S Clogg in February, 1923

HISTORY—The patient stated that in June, 1914, she had been operated upon by Sir John Thomson-Walker at the Hampstead General Hospital and that her right kidney had been removed. Up to July, 1922, she had been perfectly well, but while walking in her home her leg gave way, she then fell and was unable to get up. She felt no pain at the time. She was seen by her doctor, who diagnosed fracture of the right femur and admitted her into the local Cottage Hospital where the limb was splinted. She was allowed up in a chair in November, and while being wheeled about she slipped off the



FIG 186—Lateral view of fracture

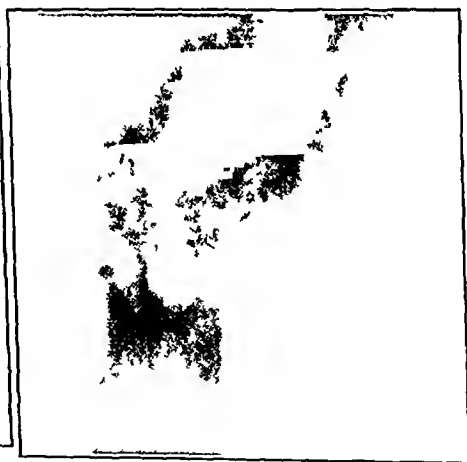


FIG 187—Anteroposterior view

chair and injured her right femur again. The limb was re-splinted, and soon after a swelling appeared in the upper third of the thigh.

CLINICAL EXAMINATION—There was a large tumour about the size of a coconut in the upper third of the right femur. The swelling was more noticeable on the anterior aspect of the thigh. It was tender, tense but elastic, with indefinite edges. There was no sign of inflammation. It was attached to bone but not to skin or muscle. A distinct impulse could be detected in the tumour, synchronizing with the heart-beat, and on auscultation a bruit was audible all over it. The distal pulse was unaffected. Further clinical examination proved fruitless.

RADIOLOGIST'S REPORT (*Figs 186 and 187*)—"General decalcification of femur Pathological fracture of the shaft Considerable destruction as a result of malignant growth Difficult to say what the type of growth is, as the fracture has confused the picture Most likely a secondary carcinomatous deposit or an endosteal sarcoma"



FIG 188—Section of the tumour

OPERATION — A diagnosis of secondary hypernephroma was made and disarticulation at the hip joint was performed by Mr H S Clogg, followed by an excellent recovery

By kind permission of Sir John Thomson-Walker the following report was subsequently received from the Hampstead General Hospital

"Mrs E T, age 61, admitted on June 25,

1914, complaining of hæmaturia and painful micturition

Previous History—Recent acute attack of abdominal pain and hæmaturia, and a small amount of hæmaturia two years previously

Examination — Right kidney movable, reaching down to the anterior superior spine

Cystoscopy — Right ureter normal in position, large open rigid orifice with sharp edges It contracted but did not close fully Left ureter normal

July 31, 1914 —Right kidney removed Large hypernephroma at the upper pole

Aug 29 —Discharged fit"

FUNCTIONAL ACTIVITY OF REMAINING KIDNEY—Urea in 24-hours' specimen 15 per cent

Urea concentration test First specimen, 1 per cent, second specimen 24 per cent, average, 17 per cent

Blood urea, 14 mgim per 100 cc of blood retention

This is below normal

This does not indicate any

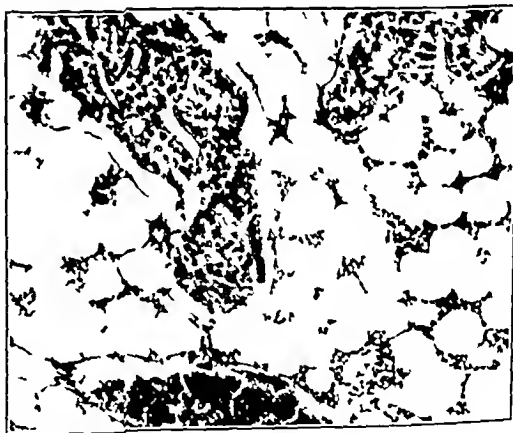


FIG 189—Showing hypernephroma cells within the lumen of blood vessels

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Subsequent X-ray examination for other bone metastases proved negative except that there was "collapse of fifth lumbar vertebra. Hardly any of the centrum remains. Lateral displacement of the fourth and fifth lumbar vertebrae." This can hardly be regarded as another secondary growth in the spine but it is suggestive, and further clinical evidence is not yet forthcoming.

MICROSCOPY OF THE TUMOUR—A section from the growth (*Fig 188*), shows the typical appearance of a hypernephroma, and it bears out in a striking manner the statement of the true mimicry which secondary hypernephromata exhibit for their parent tumour.

Fig 189 shows a section taken from another part of the tumour in which hypernephroma cells are seen within the lumen of the blood-vessels. This will be referred to subsequently in discussing the dissemination of hypernephroma, and it may be added here that prolonged search for any tumour cells in the substance of the periosteum both proximal and distal to the tumour, proved negative.

NAKED-EYE APPEARANCES—*Fig 190* is a drawing of the femur, which has been split longitudinally on opposite sides above and below the tumour. *Fig 190a* shows the spread of the growth down the medulla in the upper half of the bone where as *Fig 190b* shows the line of cleavage of the fracture with normal medulla below. This is a good illustration of the point raised by Piney¹ who

maintains that secondary malignant tumours in bone are blood-borne, and begin in the red marrow of the proximal long bones which comprises a small area at the upper end of the diaphysis. The red marrow consists of innumerable blood channels with thin walls. Consequently there must be considerable widening of the blood stream with a corresponding decrease in

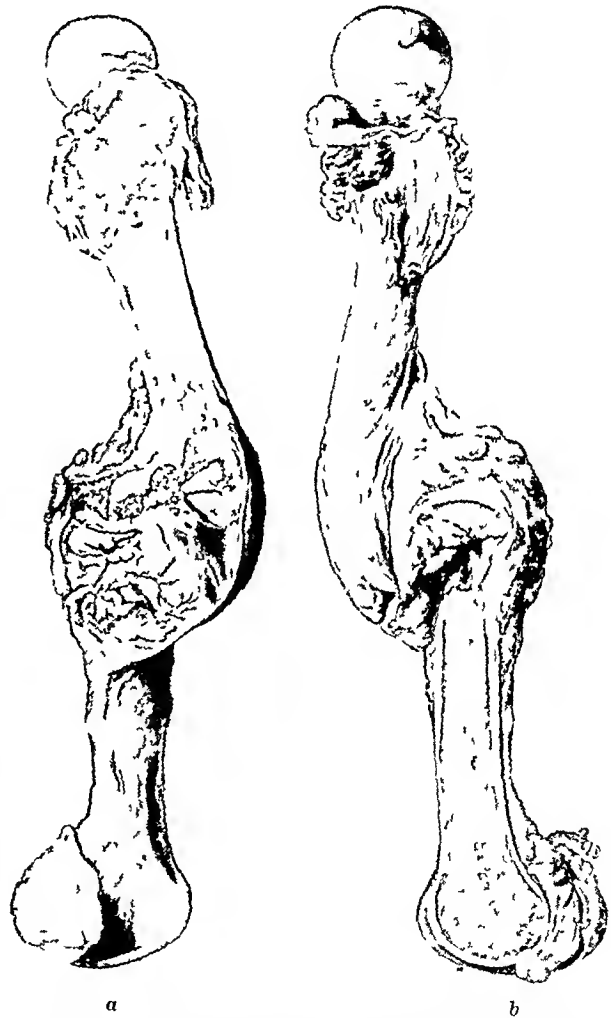


FIG 190—*a*, Showing the growth and the involvement of the medulla above it. *b* Showing line of cleavage of the fracture and no extension of growth down the medulla of lower end of femur.

the rate of the blood-flow, factors favouring the lodgement and growth of malignant cells in circulation. As soon as the deposit starts growing it spreads down the medulla, and spontaneous fracture takes place lower down where the compact bone is thinner. The same author adds that he can detect no lymphatics in bone-marrow.

Piney¹ has drawn attention to very definite changes which occur in the blood picture, and the case under review although not quite typical is sufficiently characteristic for the diagnosis of metastasis in bone-marrow to be made.

In the present case the following blood-count was made subsequent to the disarticulation of the limb, so that the degree of anæmia is probably pronounced —

Reds	4,280,000
Hæmoglobin	70 per cent
Colour index	0.8
Whites	13,000 per c mm
Polymorphonuclear	82.5 per cent
Small lymphocytes	9.0 " "
Large lymphocytes	0.5 " "
Myeloblasts	1.5 " "
Eosinophils	0.5 " "
Large lymphines	5.5 " "
Myelocytes	0.5 " "
No nucleated reds seen while counting 100 whites	

Summary of the diagnostic changes exhibited in this count —

1 A slight leucocytosis, characterized by the presence of myeloblasts and myelocytes.

2 A slight reduction in the number of reds with a relatively high colour index.

This differs from a post-operative anæmia, where there is a low colour index, increased white count, and an absence of myeloblasts and myelocytes, and also from a pernicious anæmia or the septic anæmia described by Hunter, which are characterized by —

1 Reduction in the number of red corpuscles, with a colour index above 1.

2 Slight leucopenia, with relative lymphocytosis.

3 Myeloblasts and myelocytes rare.

4 Nucleated red corpuscles always present.

Keyser and Foulds,² in an article on "The Extension of Hypernephroma by the way of the Renal Vein" investigated a case with the following history. A man complaining of hæmaturia had his right kidney removed for hypernephroma. Two months later he developed a pulsating swelling in his tibia, and died seven months afterwards.

Many sections of this kidney were cut, with the following results. Blocks of the renal artery, pelvis, and ureter showed no abnormality. Those of the main renal vein showed extension of the growth by this route. Its lumen was filled with hypernephroma cells, and the walls showed leucocytic but no tumour infiltration and there was no tendency of the tumour to perforate the wall of the vessel. The smaller radicals of the renal vein showed destruction of their endothelial lining, but again there was no mural invasion.

by growth although the walls were thinned by pressure. In the lumen of the venules in the renal tissue growth was detected with no invasion of the walls, although it was difficult to say whether these were veins or lymphatics. The authors conclude that they were the former.

This raises the question of the evidence upon which the statement is based that hypernephromata are disseminated by lymphatics. The literature quotes many cases of metastases in the regional lymph glands and in glands unconnected with the primary growth, but is unusually silent on the question of the transference by means of the lymphatic system of the bone metastases, which form its preponderating manifestation. A close study of the lymphatic system of the kidney points to a few details which may be easily overlooked.

The lymphatic vessels form three plexuses: a deep set in the substance of the kidney, a superficial set under the capsule, which communicate freely with the third set in the perinephric fat. Four or five trunks issue from the deep set, and in the region of the hilum are joined by the superficial set, to follow the course of the renal vein and end in the lateral aortic lymph glands. The perinephric plexus drains direct into the upper lateral aortic lymph glands. A few inconstant glands are sometimes found in the hilum.

Now Keyser and Foulds state that there was no evidence of lymphatic extension, but that this investigation was unsatisfactory because the aortic glands had not been removed in the operation for nephrectomy. The same condition would obtain at an autopsy unless special care was taken to remove these tissues in a block dissection.

Caiceau³ states that occasionally the lymphatics spread this disease and in these cases the glands are enlarged. The regional glands are chiefly implicated, and rarely those of the inguinal region. Morris quotes a case where the glands involved were of much greater size than the primary growth in the kidney. It is also said that secondary deposits may give rise to metastases in the glands draining the region in which they are situated.

Cases—To emphasize the difficulties in the diagnosis and the vagaries of the secondary manifestations in which the primary growth lies dormant, the following quotations from the literature are given—

Paul Albrecht⁴ records four such cases. The first is that of a man, age 60. His first sign was a spontaneous fracture through the lower third of the left femur. For this amputation was performed through the upper third. The condition was diagnosed as a myeloid sarcoma. Five years later a tumour appeared in the lower third of the right femur, another in the jaw, a third the size of a hazel nut over the third rib, and a fourth as a pulsating swelling in the skull. A year later his remaining femur fractured spontaneously, and a similar fate befell his left humerus in its upper third. At the autopsy a hypernephroma was found in his left kidney, with additional metastases in the bladder, lung, omentum, pancreas, and heart.

The second, a man age 42, developed a lump over the right frontal and parietal bones, which was diagnosed as an osteosarcoma. He died during the operation and the tumour was found to be a hypernephroma.

The third was a man, age 48, who had a fluctuating swelling of the knee, which was thought to be tuberculous. Amputation was performed and the condition was found to be a hypernephroma of the lower end of the femur. The urine remained normal, and the patient later developed a tumour of the right kidney and metastases in the right side of the head and in the metacarpal bone of the right middle finger.

The fourth was a woman, age 66. She complained of a lump over the clavicle, which was diagnosed as a cold abscess. At the post-mortem there was a hypernephroma in the left kidney, and in addition metastases in the left humerus, another below the right kidney, and a small one in the left lung.

Macleod and Jacobs⁵ record two cases of secondary hypernephroma in the sternum which were diagnosed as aneurysm. Muescholl⁶ records the successful removal of a hypernephroma in a woman of 30, which grew from the posterior abdominal wall, between the spine and the left kidney. It was adherent to the pancreas and had no connection with the kidneys or suprarenals.

Baumgarten⁷ describes a case of 'malignant neoplasm' which remained the same size for twenty years with no disability. Its origin was in an accessory suprarenal between the layers of the transverse mesocolon, which derived its blood-supply from an anomalous vessel. It was successfully removed and the patient remained well for a time and then developed pain in the left upper arm and the eighth right rib, later pain in the left femur and a swelling of the humerus. Before death she coughed up 'bloody sputum'. Unfortunately no result of the autopsy was added.

Bullowa¹⁵ records the case of a man, age 61. He complained of pain in the right groin and right side radiating to the back. Two weeks later he developed a swelling in the right groin. He was operated upon for right hernia. Later he developed a lump over the twelfth dorsal vertebra which pulsated and emitted a bruit. Paraplegia followed and then death. At the post-mortem a hypernephroma the size of a tennis ball was found in the upper half of the left kidney, it was encapsuled and there was no extension into the veins. The lump in the right groin proved to be metastases in the glands.

Prognosis—The prognosis of hypernephroma makes gloomy reading. On the whole the statistics given are fairly uniform and raise interesting points of relative value.

Keen, Pfahler, and Ellis⁸ give the duration of the disease as from fifteen weeks to eight years, with an average of two and a quarter years. Richards's⁹ average works out at two and a half years, and Carreau's¹⁰ at three and a half years. The expectation of life is very much shortened on the appearance of metastatic deposits, although Albiccht¹¹ describes a case which was alive and well two years and seven months after the removal of metastases in the scapula, the kidney having been removed four years previously. The same author describes a series of 16 nephrectomies, of which only 4 were alive after four years, of the latter, metastases appeared in 3. In another series of 24 operations only 1 was alive four years after the operation.

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Carreau¹⁰ gives a comparative list of 143 nephrectomies. Of these the immediate mortality was 33, 43 died later after operation, 31 survived, and in 36 cases the results were not stated. Of the 43 who died later after operation, 22 died within the first year, the cause of death being metastases elsewhere.

The following table shows the length of time which elapsed between nephrectomy and death from metastases in 33 cases.

PERIOD	NO OF CASES	PERIOD	NO OF CASES
1 year and under,	17	4 to 5 years,	1
1 to 2 years,	8	7 " 8 " "	1
2 " 3 " "	4	10 " 11 " "	1 = 33
3 " 4 " "	1		

The duration of life in the 43 cases who died later after nephrectomy was as follows —

PERIOD	NO OF CASES	PERIOD	NO OF CASES
1 year and under,	22	4 to 5 years,	1
1 to 2 years,	11	7 " 8 " "	1
2 " 3 " "	6	10 " 11 " "	1 = 43
3 " 4 " "	1		

The fate of the 31 survivors after operation is shown in the following —

PERIOD	NO OF CASES	PERIOD	NO OF CASES
1 year and under,	9	4 to 5 years,	3
1 to 2 years,	6	5 " 6 " "	2
2 " 3 " "	7	6 " 7 " "	1
3 " 4 " "	2	9 " 10 " "	1 = 31

Site of Metastases—In Carreau's list the main metastases are given as follows: Bone 35, lungs 21, liver 8, regional lymph glands 11.

In the bone cases the relative frequency was: Femur 7, vertebrae 7, ribs 6, skull 5, clavicle 2, pelvis 2, humerus 2, scapula 1, jaw 1, tibia 1, metacarpus 1.

All parts of the body may be involved, although there is occasional immunity. Albiccht¹³ gives 15 cases in which bone metastases appeared in 8, and lung metastases in 7. He also says no spread along the urinary tract has been detected. H. L. Krietschne¹⁴ describes hypernephromatous nodules in the skin.

Blood Changes—With regard to blood changes accompanying secondary deposits in bone the literature only contains two fleeting references. Keyser and Foulds² give the following blood-count in their case quoted above: Erythrocytes 3 450 000, leucocytes, 10,000, hæmoglobin 54 per cent. Here there is definite anæmia which may be accounted for by the hæmorrhage.

Bullow¹⁵ in a case of hypernephroma with spinal metastases, gives the following differential white count: Leucocytes, 9200 polymorphonuclears 72 per cent, transitionals, 2 per cent, lymphocytes 25 per cent.

SUMMARY OF THE CASE

1 The interesting point of this case is the length of time—nearly ten years—before the appearance of a bony metastasis after the removal of the kidney, the longest time quoted in the literature being ten years

2 The site of fracture is the usual one, and the position of the secondary growth is in its usual position

3 The conclusion is formed that the dissemination of secondary hypernephroma in bone takes place via the blood-stream, and the evidence is based on the detection of tumour cells within the lumen of the blood-vessels, and also on the absence of any infiltration of the lymphatic channels, especially those in the periosteum above the tumour

I have pleasure in acknowledging my indebtedness to Mr H S Clogg for allowing me to publish this case, also to Dr Alfred Piney for his help and for photographing the sections

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PAGET'S DISEASE OF THE NIPPLE.

BY SIR GEORGE LENTHAL CHEATLE, LONDON

INTRODUCTION

I PROPOSE to attack the problems involved in this article and arrive at definite conclusions concerning them by means of reproductions of whole sections of eight breasts suffering from Paget's disease of the nipple. The sections have been cut in paraffin by a microtome I had specially constructed, and they can be examined by a one-twelfth oil-immersion lens. There is no likelihood of being able to demonstrate and solve the problems connected with Paget's disease of the nipple without the aid of such sections of the breast cut in series. Further evidence is also included that has been gained from the examination of small sections from other breasts similarly affected.

I shall first refer to certain anatomical points that are important, then, after showing where Paget's disease of the nipple begins, proceed to describe the appearances of the disease in its different stages and finally to place in correct relation to it the glandular carcinoma that is usually associated with it. In doing so I endeavour to adduce cogent reasons for considering that Paget's disease of the nipple is a primary malignant disease, also that

the glandular carcinoma of the breast to which I have just referred is a secondary process, although it is a primary carcinoma arising in the epithelial cells of the gland. Further I wish to enunciate what almost amounts to a law. That carcinoma arising in the breast below a line drawn parallel with the top of the nipple and immediately below the expansions of the outlets of mammary ducts (Fig 191) does not induce Paget's disease

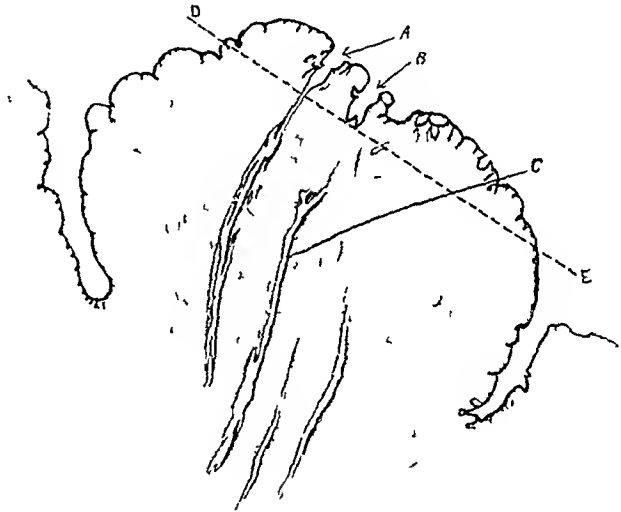
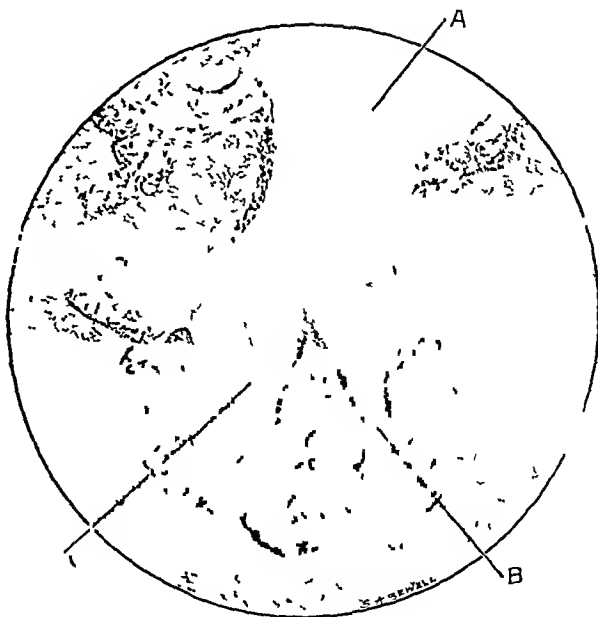


FIG 191.—Drawing of a normal nipple. At A is a duct outlet. Into this the duct can be seen opening. B is a duct outlet containing the openings of two ducts. C is one of the ducts which open into this outlet. D E is the imaginary line which I have described in the text as being drawn parallel to the surface of the nipple below the duct outlets. It must be very rare for any carcinoma of the breast arising below this line to induce Paget's disease of the nipple.



FIG 192—High power photograph of a duct outlet which contains a plug otherwise it is normal A is a sebaceous gland the duct of which can be seen opening directly into the outlet A₁ is another sebaceous gland The arrow at B points to the surface of the nipple The arrow at C points to the opening of a duct and shows its epithelium becoming a thin layer and passing from the squamous towards a columnar type

FIG 193—A plugged duct outlet, A affected by Paget's disease of the nipple Opening into the outlet are two ducts, B and C into which the plug extends B is the end of the duct D in Fig 205, and C is the outlet of the duct A in Fig 194



Anatomical Points—A mammary duct widens as it opens on to the surface on the top of the nipple. Into this outlet open the ducts of sebaceous glands which surround it (*Fig 192*). The outlets of the mammary and sebaceous ducts are lined by the same type of epithelium as that which covers the nipple and its areola. Two ducts may terminate in one outlet (*Figs 191 and 193*). The outlets of mammary ducts frequently contain plugs (consisting of desiccated shed epithelium and possibly sebuni), which may extend a little way into the ducts (*Fig 193*). The epithelial lining of a duct before reaching its outlet is in a transitional state, and is not columnar in type. The plugs may act as irritants, or their presence may encourage the action of other agents of irritation. A duct, whether its outlet be plugged or not, could under certain conditions act as a pathway to the deeper parts of a breast for agents of irritation (*Figs 191 and 194*).

To show the possibility of cutaneous ducts acting as pathways for living agents of irritation, it is interesting to point out a cutaneous gland in which lies a nematode worm which gained entrance by means of a duct (*Fig 195*). In other cutaneous glands worms of the same nature existed in different stages of evolution. The observation is new and was discovered accidentally by my assistant, Mr S J Mitchell, while preparing specimens for me of the normal skin of the frog.

It is also interesting and instructive to remind the reader that the basal epithelial cells lining the structures above the line referred to are pigmented especially in women who have been pregnant.



FIG 194—Shows a plugged duct outlet at A affected with Paget's disease of the nipple. Into the outlet is leading a duct, the upper part of which is filled with carcinoma cells B which can be seen ending abruptly. The carcinoma somewhat resembles Paget's disease of the nipple. The cells have proliferated, were vacuolated and had multiplied to the extent of filling and dilating the duct. There were no concentric bodies in these cells. The normal epithelium lining a duct at this part is undergoing a gradual change from the squamous to columnar type. At D a collection of cells is seen resembling those in the tumour at B. A normal duct at this part is lined by columnar cells. As these cells at D are not columnar it is possible that they have been transplanted from B. C is the columnar cell carcinoma in the duct D in *Fig 205*. The duct outlet, A is part of the outlet C in *Fig 193*.

The importance of this lies in the fact that Paget's disease of the nipple begins in the deeper layer of epithelial cells, and certain observers, notably Dr Arthur Whitfield, regard the epithelial changes in that disease as similar

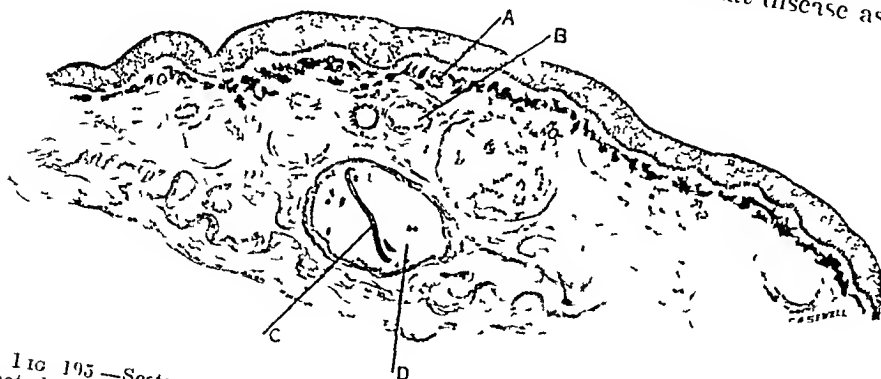


FIG 195.—Section of a frog's skin. At D is a cystic cutaneous gland in which there is a nematode worm C which gained entrance by means of the duct A B. The specimen appears to be unique for no authorities whom I have consulted appear to be aware either of the condition or of the nature of the nematode worm. The parasite existed in a few more glands in various stages of its evolution. The condition seen in this section shows that ducts can be dangerous pathways for agents of disease.

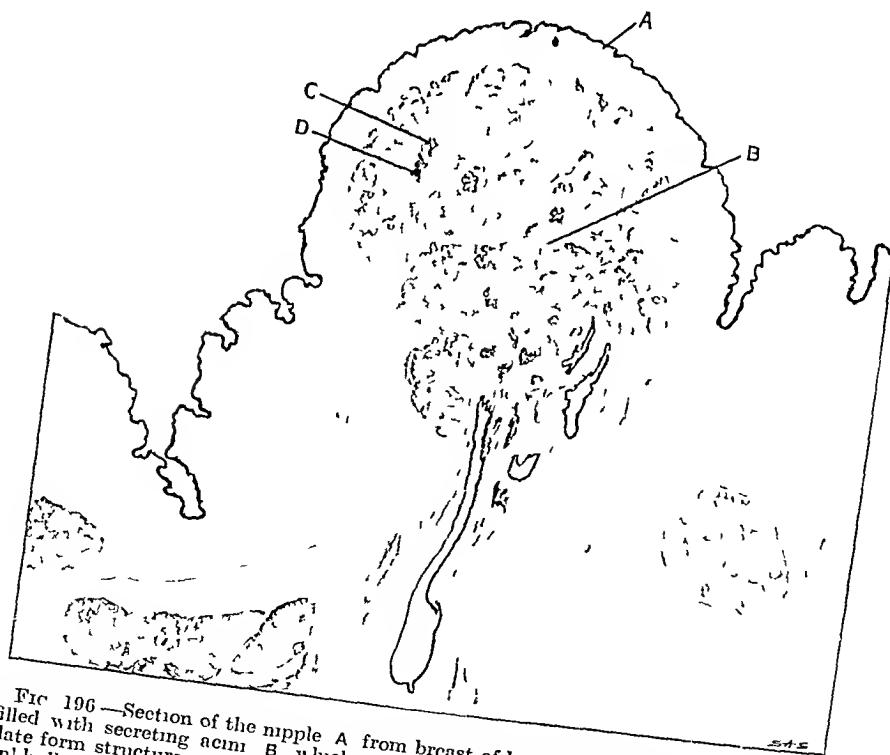


FIG 196.—Section of the nipple A from breast of lactating female age 36. The nipple is filled with secreting acini B which extend up to the normal epithelial surface the stellate form structures of which C and D are examples are ducts cut transversely. The main bulk of the nipple consists of acini.

to changes in a mole that has become malignant. In addition, the early changes in Paget's disease are remarkably like those seen in the earliest stages of rodent ulcer which also arise in the deeper layers of epithelial cells. I would like the reader to compare *Fig 213* with the figures I published in a paper on "The Multicentric Origin of a Rodent Ulcer" (*THE BRITISH JOURNAL OF SURGERY* 1922, April, p 529).

It is not proposed to say more about the resemblance between Paget's disease and rodent ulcer than that they resemble each other by beginning in the same layers of epithelium, in the occasional occurrence of epithelial cell nests, and in that in each the permeation of lymphatic vessels must be exceedingly rare.

Fig 196 is included to show that acini can be present in the nipple and that therefore a carcinoma beginning in the nipple may be acinous and not necessarily of duct origin. This nipple is full of secreting acini which extend up to the true skin of its surface. The specimen came from a lactating bicast of a woman three months after parturition.

SITE OF ORIGIN OF PAGET'S DISEASE OF THE NIPPLE

It is now my object to show that Paget's disease begins as a primary disease in epithelial cells situated above an imaginary line drawn parallel with the surface of the nipple immediately below the expansions that occur in the mammary ducts before they terminate upon the surface of that structure. In addition, attention is drawn to certain facts suggesting that a common site of origin is possibly in the outlet of a mammary duct.

First it may be stated that a carcinoma beginning below that line is very rarely associated with Paget's disease of the nipple. This is so in spite of the fact that many carcinomas grow in masses right into the nipples and reach the epithelial surfaces without inducing any changes in them. In other

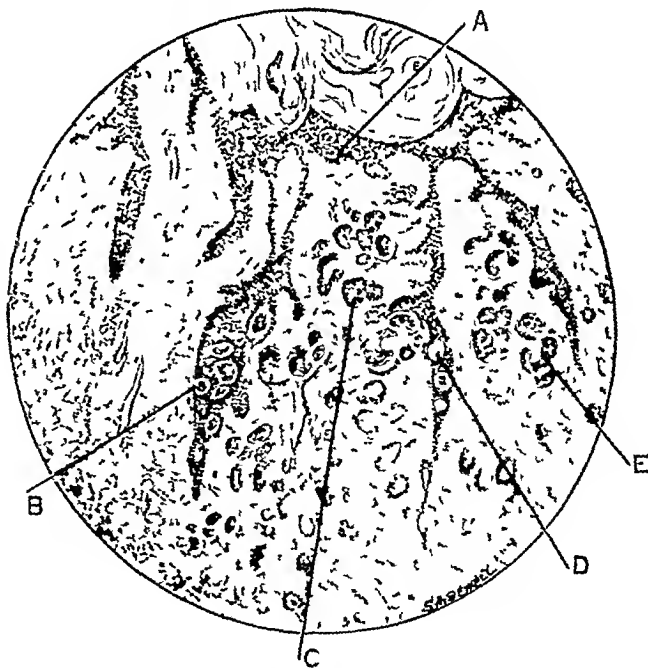


FIG 197—Upward growth of a carcinoma C and E originating below the line to which I refer in the text (see *Fig 191*). A is the surface epithelium of the nipple, in which foci of the carcinoma can be seen. Collections of cells from C and E can also be seen in the surface epithelium at B and D. The surface epithelium has not undergone any changes excepting those due to pressure of the invading cells of the tumour.

specimens the lymphatic vessels of the nipples are permeated with carcinoma.

cells in small or great degrees, also without any signs of Paget's disease. A carcinoma arising in the breast below that line may in some instances actually invade only the basal layers of the epidermis of the nipple, or in others it may even invade the whole of the epidermis of that structure without inducing any change apart from the effect of pressure (*Fig 197*)

I now describe two examples of quite superficial carcinoma that began in the nipples just below the imaginary line without inducing Paget's disease. The first specimen is that which Sir Hugh Rigby kindly allows me to publish of a duct carcinoma of the breast. There was no Paget's

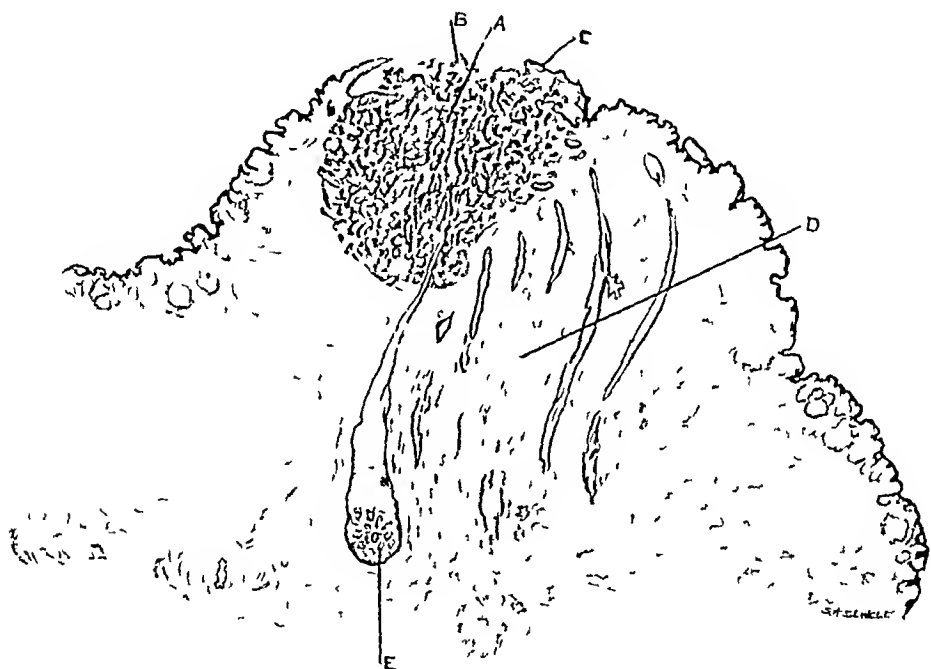


FIG 198—Low power reproduction of the nipple and contained duct carcinoma from a patient under the care of Sir Hugh Rigby. The surface epithelium of the nipple which is intact at B C shows no sign of Paget's disease. E is a duct containing a large multiradicular papilloma of doubtful nature. The tumour began below the imaginary line DE of *Fig 191*.

disease (*Fig 198*). The carcinoma was of a particularly malignant type and the axillary lymphatic glands were implicated. The primary tumour was in the nipple, and was so small that its detection required careful palpation. There was hæmorrhage from the nipple. The patient was unmarried, age 36 years.

The pathological report was "Tubular and intratubular papillary cuboidal cells, rarely squamous and horny, carcinoma of duct of nipple." There is also a large multiradicular papilloma existing in the duct at E, *Fig 198*. The papilloma is not in continuity with the tumour above it. The surface epithelium has been shed in parts, in other parts where it is covering the papillæ of the true skin it is either perfectly normal or has

been killed *in situ* without undergoing Paget's disease. I have another almost precisely similar specimen (Fig 199). The portion of surface epithelium selected for reproduction is typical of the whole of the surface from which it came. This tumour also began just below the imaginary line without inducing Paget's disease. Here are two wonderful examples of a common and usual state of things.

In the whole of my collection I have only one specimen that can support the view that Paget's disease of the nipple is a secondary consequence to the upward spread of a subjacent carcinoma. I reproduce it in Fig 200 where Paget's disease is affecting only a few basal cells in the epidermis of the nipple and a duct wall.

The basal cells have separated from each other, they have lost their prickles, they have become vacuolated, and after multiplication they have invaded deeper tissues. A few concentric cell inclusions can be seen. This is the smallest lesion of the kind I have seen and it induced no visible clinical change in the top of the nipple where it was situated. Dr Arthur Whitfield and I consider it to be an early Paget's disease of the nipple. The breast contained a large carcinoma that extended up to the side of the areola. The nipple was free from invasion by this carcinoma. This specimen might be regarded by some as evidence in support of the

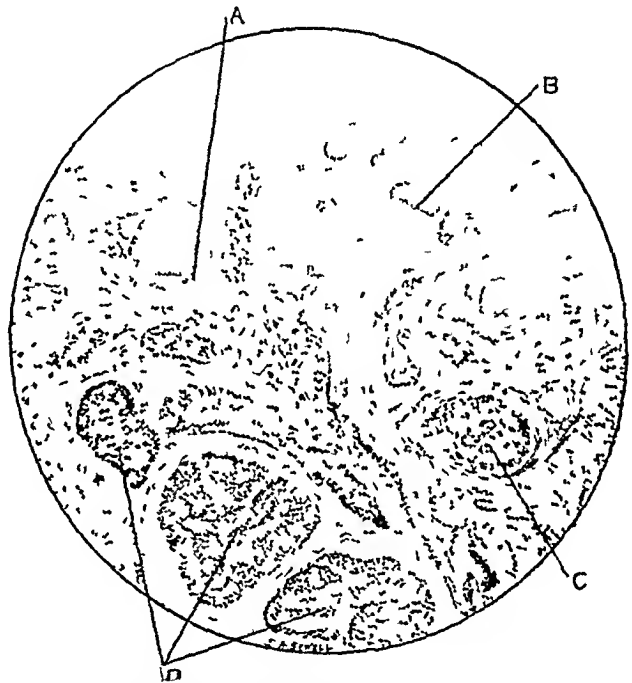


FIG. 199.—Low power reproduction of a duct carcinoma of the nipple (female) which began below the line DE of Fig 191. The surface epithelium was intact at A and B and shows no sign of Paget's disease. Lymphatic vessels below the surface epithelium of the nipple are filled with carcinoma.

idea that Paget's disease is due to the previous existence of subjacent carcinoma. It would be difficult, however, to believe that so large an underlying carcinoma had induced so minute an area of Paget's disease.

My explanation of the pathological changes in this specimen will be seen later to be as follows. Paget's disease of the nipple is carcinoma which in this instance has either begun independently, or possibly as an exception to my rule, has occurred as a primary disease as a result of the action of the same agents that induced the underlying carcinoma of the breast.

I am glad to say many authorities agree with me in describing as carcinoma a process of epithelial hyperplasia that is considered by others not to be carcinoma. To make myself clear I will attempt to show how it

is that there is an element of disagreement on the subject. Take the upper part of the longitudinal duct in *Fig 207*, and imagine a transverse section of it at *E*, it would have shown a dilated duct full of multiplying epithelial cells, abnormal in character, which show no evidence of invading the connective tissues. Therefore it is said that the contents of the duct cannot be carcinoma. Now imagine that another transverse section of this duct had been made at *A* in *Fig 207*. Here a dilated duct full of the same growth would have been seen but at one point invasion of the duct walls is so perfectly obvious that all would agree that the lesion is carcinoma. My opinion is that carcinoma is present in both of the imaginary transverse

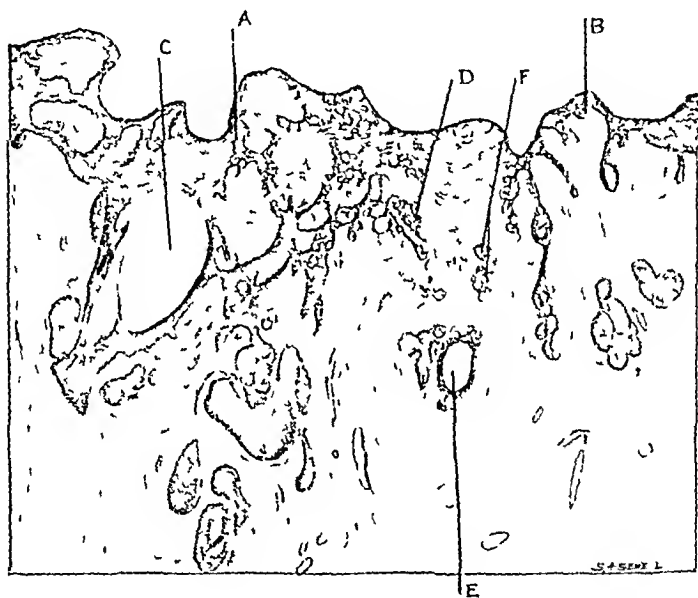


FIG 200.—Low power reproduction of top of the nipple with the smallest area affected by Paget's disease (between A and B) that I have ever seen. A mass of subjacent carcinoma was growing upwards from the subjacent breast which had reached the areola on one side of this nipple. There was no carcinoma of the nipple excepting the Paget's disease of its epithelium. D is Paget's disease of the nipple where the invasion is most marked. E is the affected and plugged termination of a duct just before it reaches its outlet. F is the edge of the affected outlet into which E leads. Epithelial cells from E and F are invading the surrounding structure. C is a plugged duct outlet but otherwise is normal.

sections. I humbly believe that many of those who disagree with me now will agree with me when they become more fully acquainted with all that whole sections of breasts can teach them.

I will now produce further evidence to show that Paget's disease begins as a primary disease in the epithelium situated above the imaginary line already indicated. It would be interesting and perhaps more conclusive to my thesis that the breast carcinoma is secondary to the Paget's disease of the nipple, if I could show a specimen of the latter that was not associated with the former. Failing this evidence it is important to point out that the condition does occur elsewhere than in the nipple as a primary disease and in the absence of any other form of carcinoma for example, see

Fig 201 During six years Paget's disease of the nipple had been slowly spreading in the skin covering this patient's abdomen in the absence of any other form of carcinoma in the body. The lesion here depicted was carefully examined microscopically.



Fig 201 — Paget's disease of the nipple on the abdomen of a man age 49. The disease was carefully examined microscopically. The lesion had been spreading for six years. I published this photograph previously in order to show the limitation of the lesion to the tenth dorsal nerve area. Excepting for the presence of this disease there was no carcinoma in the body for six years.

To prevent constant repetition I may say at once that I have no specimen that does not show in at least one duct the changes seen in the duct at *B* in *Fig 210*. There is evidence in all of a direct continuity between carcinoma in a duct and in the disease on the surface. The continuity of disease may not persist and is liable to reappear after interruption (*Fig 216*). These facts could be taken as arguments in favour of Paget's disease of the nipple being a secondary disease to the presence of carcinoma in the upper duct region. Such arguments are refuted by the statement that if the carcinoma in the duct were primary and Paget's disease were secondary then the latter would be a common and not a rare condition. Also the fact must be borne in

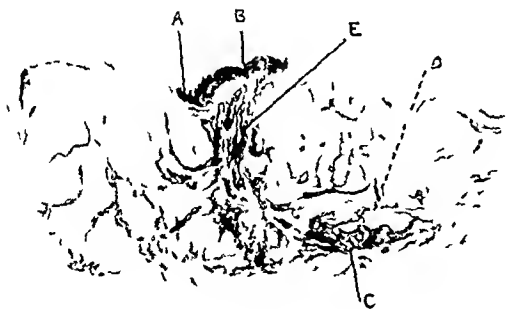


Fig 202 — Plastic stained whole section of Paget's disease of the nipple. Female age 48, married. Between *A* and *B* is the nipple, and at *A* part of the areola. *A* and *B* mark the limit of the disease. *C* marks the position of a duct and its branches full of a multitruncular papilloma which is seen under higher magnification at *A* and *C* in *Fig 204*. *E* is the duct of which *C* is a continuation. There is no carcinoma in the upper parts of *E* nor in any of the other ducts of the nipple. The elastica in *E* has undergone greater hyperplasia than any other duct in the breast. The dotted line *D* marks the position of the acinous carcinoma in the next section of the series, which is seen at *A* in *Fig 203*.

mind that Paget's disease can be multicentric in origin and foci of multicentric origin occur in parts on the surface of the nipple that are not in continuity with carcinoma in a duct (*Fig 213*).

An extensive Paget's disease of the nipple is reproduced in *Fig 202*. The whole of the normal surface epithelium of the nipple and that of a large area of the areola has been destroyed by the disease. Apart from the carcinoma in the upper regions of two ducts, after an exhaustive search for a further carcinoma of the breast I discovered an unsuspected small area not bigger than a split pea at *A*. *Fig 203* in the depths of the gland. It had only infiltrated the connective tissue around it. In no part of the breast were there therefore the lymphatic vessels

any permeated lymphatic vessels and

subjacent to the diseased area on the surface contained no carcinoma. In a duct at C *Fig 202*, there was an extensive and unsuspected multiaxillary



Fig 203—Reproduction of the next section in the series to *Fig 202* situated at the position of the dotted line D in *Fig 202*. A The acinous carcinoma (two thirds natural size) to which reference was made in describing *Fig 202*. The carcinoma is infiltrating the surrounding tissue. B represents the position of the nipple. In no parts of the breast were any lymphatic vessels to be seen containing carcinoma. Besides the Paget's disease of the nipple and carcinoma A no other carcinoma existed in this breast unless the multiaxillary papilloma A and C in *Fig 204*, contain a duct carcinoma.

activity in the acini (*Fig 205* at E and *Fig 206* at A) as well as in one duct (*Fig 205*, D). In another duct there is a limited activity of epithelium which is in continuity with the disease in its outlet (*Fig 194*). The outlet is common to both these ducts (*Fig 193*). It is interesting to observe in these two ducts that there is so much more epithelial activity in one than in the other. I believe carcinoma exists in both ducts, but while in *Fig 207* it has reached the stage of invading the walls of the duct, in *Fig 194* it is still limited to the natural walls of the duct. There is another fact to be observed in that part of the disease which has spread to the areola viz the ducts of the sebaceous glands and the hair follicles have been attacked by Paget's disease of the nipple (*Fig 208*). I could not discover permeation of lymphatic vessels by carcinoma cells in any part of this breast. Again, it is difficult to assume that the carcinoma in this breast could have induced the Paget's disease

papilloma, the cells of which were all contained within the duct (*Fig 204*). It may be an example of an early duct carcinoma, but if it be it is one that has not transgressed the natural boundaries of the duct. The difficulty in assuming these tumour formations to be an inducing factor of the Paget's disease on the surface is too great. I can only believe that the disease on the surface of the nipple was primary.

Another specimen of Paget's disease of the nipple about the same in extent as that in the above figures is reproduced in *Fig 205*. In a segment of this breast there is much epithelial

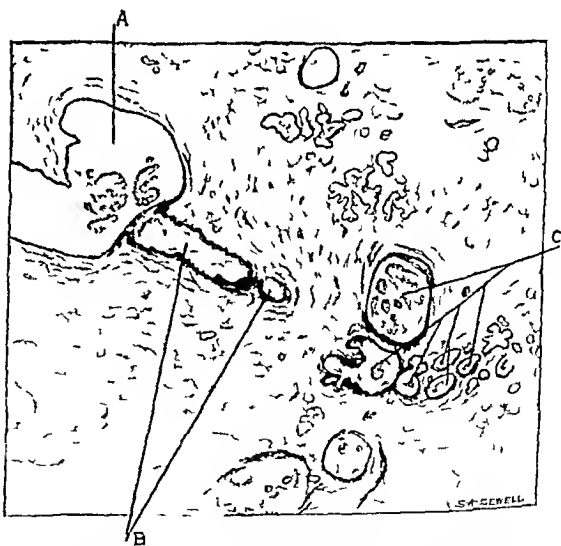


Fig 204—A B and C are branches of the duct C in *Fig 202* under higher magnification. A and C can be seen full of multi-axillary papilloma. Part of the duct B contains semi-organized tissue containing a few connective tissue cells embedded in fibrous looking material. It may be the result of a haemorrhage. There are no epithelial cells in this part of the duct.

Fig 209 represents a small lesion of Paget's disease limited to the top of the nipple. Two mammary duct outlets are affected with Paget's disease. In one only (Fig 210) is carcinoma present in the duct belonging to it. After examining whole sections of this breast I could find no other carcinoma except a few lymphatic vessels that were blocked by carcinoma cells (Fig 210, D). These cells, therefore, must have originated in the small amount of carcinoma in the duct at Fig 210 B.

In all the above specimens which are examples of the usual conditions it would be more likely that the superficial disease had attacked the widely separated deeper structures as it spread to them one after the other, than that the deeper parts had all become affected one after the other and had then induced the superficial disease.

It may have been noticed that while describing these breasts I have stated that in those shown in Figs 203 and 205 I could not discover any lymphatic vessels containing carcinoma cells, and in that description I included those lymphatic vessels that lie beneath the Paget's disease.

I may misunderstand Mr. Sampson Handley's explanation of Paget's disease of the nipple¹ when I assume that he attributes the disease to the plugging of the subjacent lymphatic vessels by carcinoma cells. I have just shown two specimens of Paget's disease of the nipple in which the carcinoma in the breast had not reached any lymphatic vessels; therefore the nipple disease could not have been due to that cause. I have four other specimens in which some lymphatic vessels situated in other parts of the breast are certainly permeated—for example, Fig 219, from Fig 218, G—but the whole of the nipples and then areola are absolutely free from carcinoma cells.

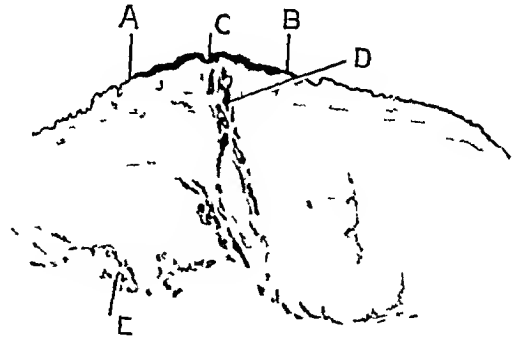


FIG. 205.—Whole section of breast affected by Paget's disease of the nipple. Female, age 49, married. A and B mark the limit of the disease which included the areola. C is the centre of the nipple. D is a duct containing duct carcinoma. E Acini that have become carcinomatous. No lymphatic vessels containing carcinoma cells could be discovered.

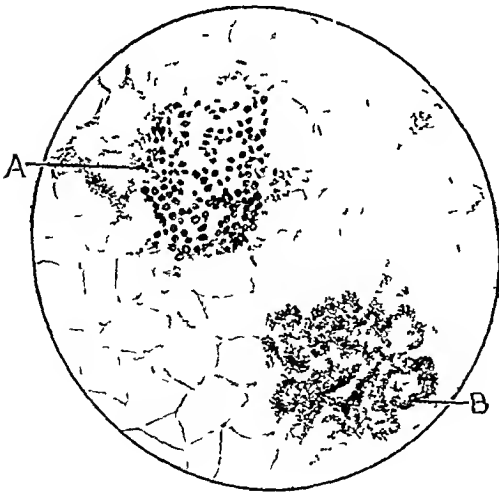


FIG. 206.—Reproduction under high power from E, Fig 205. At A carcinoma can be seen beginning to invade the connective tissue round the acinus. B A lobule the acini of which contain desquamative epithelial hyperplasia.

It is quite obvious that Paget's disease of the nipple occurs without any permeation by carcinoma cells of the subjacent lymphatic vessels. On the

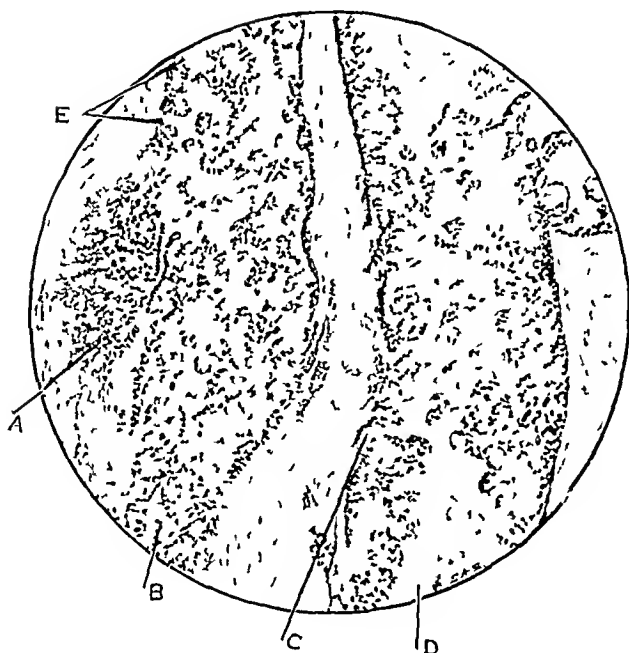


FIG. 207.—Columnar cell carcinoma occurring in two branches of the duct at D in Fig. 205. There is invasion of the surrounding connective tissue in the branch B at A and in the branch D at C. E marks a place where in the text I ask the reader to imagine that the duct has been cut transversely and to compare it with an imaginary transverse section cut at A.

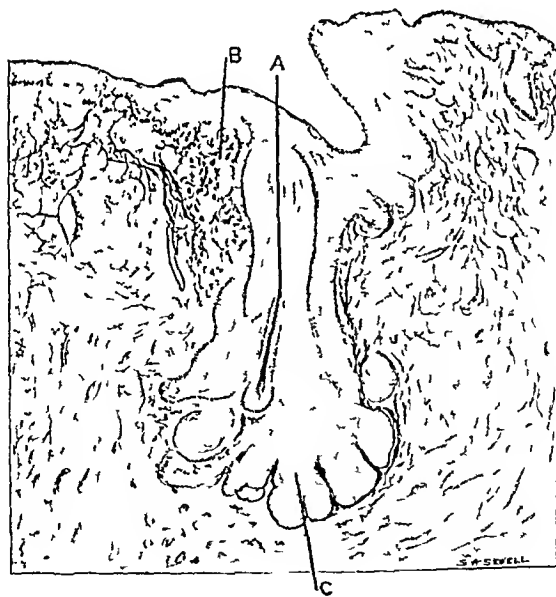


FIG. 208.—A hair follicle with its sebaceous glands reproduced under high power from the margin of the Paget's disease of the nipple of Fig. 205 at B. Paget's disease of the nipple can be seen affecting the basal layer of this hair follicle at C. A is the hair. B Paget's disease of the nipple.

other hand the vast majority of specimens in which these lymphatic vessels are plugged with carcinoma cells show no sign of Paget's disease. Moreover the condition can occur elsewhere on the body as a primary disease and in the absence of all other forms of carcinoma.

I pass on to draw attention to certain facts that suggest a close connection between the origin of Paget's disease of the nipple and the outlets of mammary ducts.

As Paget's disease of the nipple begins on the top of that structure (*Figs 200 and 209*) and not on its sides nor in the areola it seems reasonable to assume that the duct outlets which are limited to this portion must play some essential part. By the mutation consequent on their closure by plugs

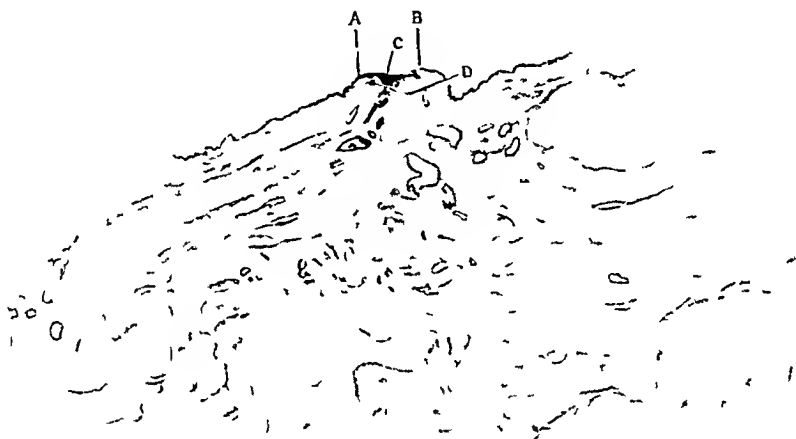


FIG. 209.—Whole section of breast affected by Paget's disease of the nipple. Female, age 52, married. Lines A and B mark the limit of the disease. C is a mammary duct outlet which leads into the affected duct that opens into it. The duct is full of carcinoma and is represented in the figure by four black marks. D is a plugged duct outlet affected by Paget's disease of the nipple. The duct which ended in this outlet did not contain carcinoma. A branch is cut longitudinally and lies a little below it. Above the duct outlet there were some lymphatic vessels plugged with carcinoma cells which must have been derived from the carcinoma in the duct leading into the outlet at C.

they appear to me to afford the essential explanation of the induction of Paget's disease.

In *Fig 210*, C will be seen a duct outlet blocked by a plug surrounded by Paget's disease of the nipple with no corresponding lesion on the surface epithelium at this part. In the same figure at A a similar blocked duct outlet is present, but in this instance the deeper duct (*Fig 210 B*) with which it is continuous contains early carcinoma, which was absent from the deeper duct belonging to *Fig 210, C*.

To complete this part of my article I must add that, had it not been for the early disappearance of almost all sebaceous glands in Paget's disease of the nipple there might be some evidence to show that it can begin in the basal epithelium of their ducts as they enter the outlets of mammary ducts or terminate upon the surface of the nipple.

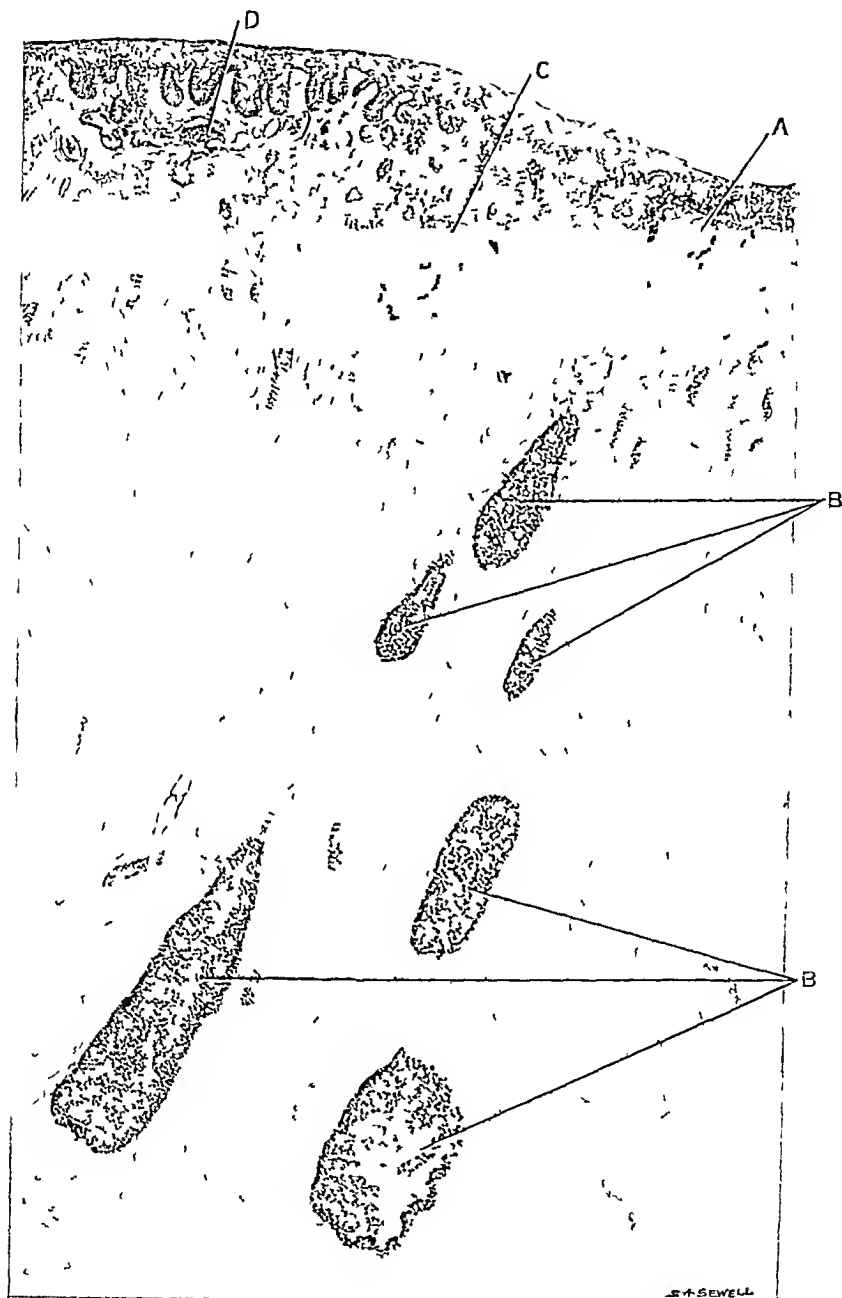


FIG. 210.—A higher magnification of part of the nipple shown in *Fig. 209*. A is a plugged duct outlet which is affected by Paget's disease of the nipple. The epidermis covering it is not affected by this disease. It appears that Paget's disease began in this duct outlet. B is the carcinoma of the duct. Its opening on the surface is not shown in this section. No trace of invasion of the connective tissues by carcinoma can be seen. C is another duct outlet affected by Paget's disease of the nipple. Its opening on the surface is not seen in this section. The duct which led into it did not contain carcinoma. It appears that Paget's disease of the nipple began also in this duct outlet. On the surface of the nipple Paget's disease existed, but it is not shown in this section. D. A lymphatic plug with carcinoma cells which must have been derived from carcinoma in the duct B as no other carcinoma except Paget's disease of the nipple existed in the breast.

THE PATHOLOGICAL APPEARANCES IN PAGET'S DISEASE OF THE NIPPLE

Having drawn attention to the fact that the disease is a primary disease in the nipple as well as elsewhere in the body, I pass on to describe the disease as it affects the nipple, and to show, incidentally reasons why I am convinced it is carcinoma. Sometimes the disease affects an isolated area which is not in continuity with any part of the main disease that exists elsewhere in the nipple (*Figs 211 and 212*). The specimen not only affords an example of the multicentric origin but it also affords a beautiful example of the disease in the early stage. A few cells of the basal layers of epithelium have become separated from one another, they have become vacuolated, they have lost their prickles, and among them can be seen an epithelial cell undergoing mitosis. These are the earliest visible indications of the disease and the presence of a mitotic figure indicates a process of epithelial activity.*

Fig 213 shows another isolated area of early disease, reproduced from

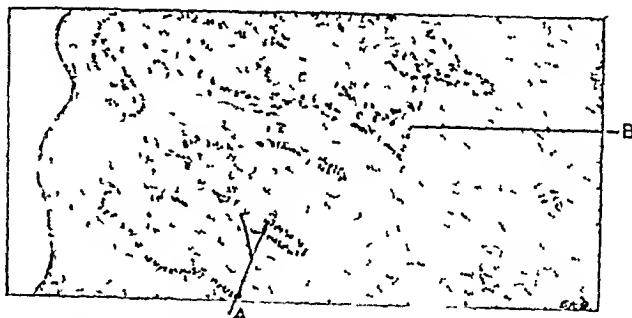


FIG 211—The edge of an isolated area of Paget's disease of the nipple in the disease of the surface shown in *Fig 202*. A is the extreme limit of the disease, and B shows invasion of basal epithelial cells after their multiplication. (See also *Fig 212*.)



FIG 212—Reproduction under higher power of A in *Fig 211*. A Connective tissue. B Epithelial cells which can be seen separated from each other. They have lost their prickles they have multiplied and on the extreme left of the section a cell has become vacuolated. At B there is an epithelial cell undergoing mitosis. These appearances represent the earliest stages to be observed in Paget's disease of the nipple.



FIG 213—Shows an isolated area of Paget's disease of the nipple in an early stage from *Fig 202*. It is not in continuity with the main disease but Paget's disease of the nipple can be multicentric in origin. At A the cells have multiplied, lost their prickles, become vacuolated and separated from one another. There is no mitosis in this section.

* I would not attach importance to mitosis as a sign of malignancy when it occurs in papillomatous tumours that are not invading deeper tissues. When it occurs in epithelial cells massed together in no particular arrangement, as in *Fig 212*, I believe the presence of mitotic figures is evidence of profoundly serious import, especially when in parts of the same disease the epithelial cells are invading deeper tissues. Some of the slowest-growing tumours have many mitotic figures, and some of the most rapidly-growing tumours exhibit only a mitosis. Paget's disease of the nipple is not usually a malignant type of carcinoma, and in many of the epithelial cells massed together in no particular arrangement there are many mitotic figures, sometimes six can be seen in one field of a one sixth objective.

another specimen In this particular collection of cells mitosis is absent *Fig 211* from *Fig 215* E is taken from the spreading margin of the main

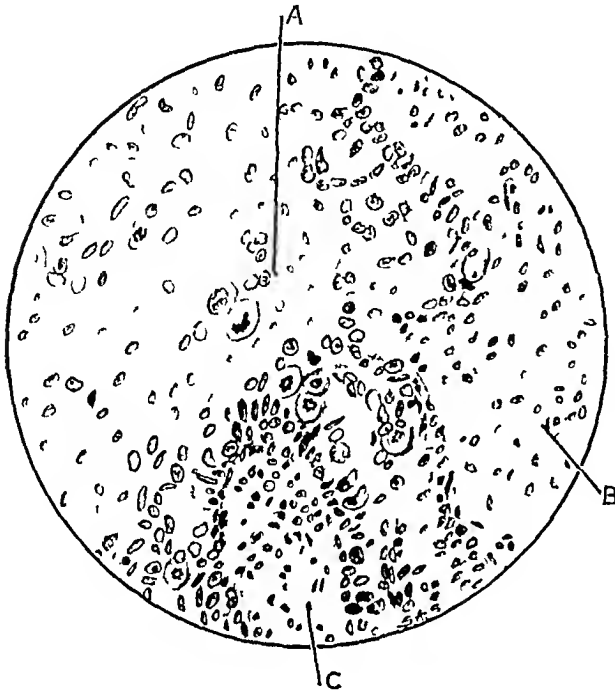
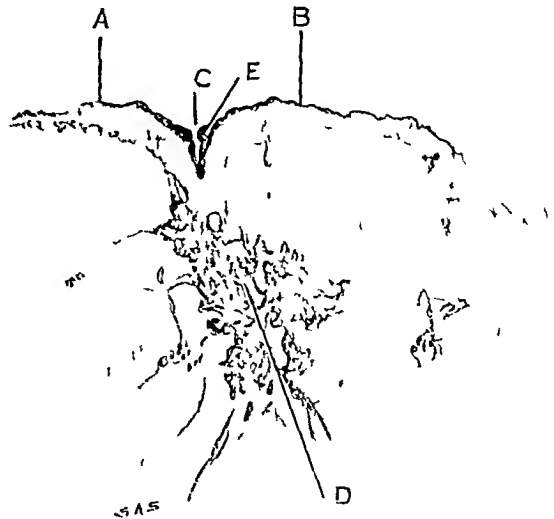


Fig 211—The edge of a duct outlet affected by Paget's disease of the nipple from E, *Fig 215* B and C are connective tissue A points to the affected basal layer of epithelial cells, among which six mitotic figures are seen The drawing does more justice to the appearance of the mitotic figures than it does to the appearance of Paget's disease of the nipple

disease in a duct outlet, and the appearances seen in *Fig 212* are repeated in every detail except that mitotic figures are more numerous in *Fig 211*

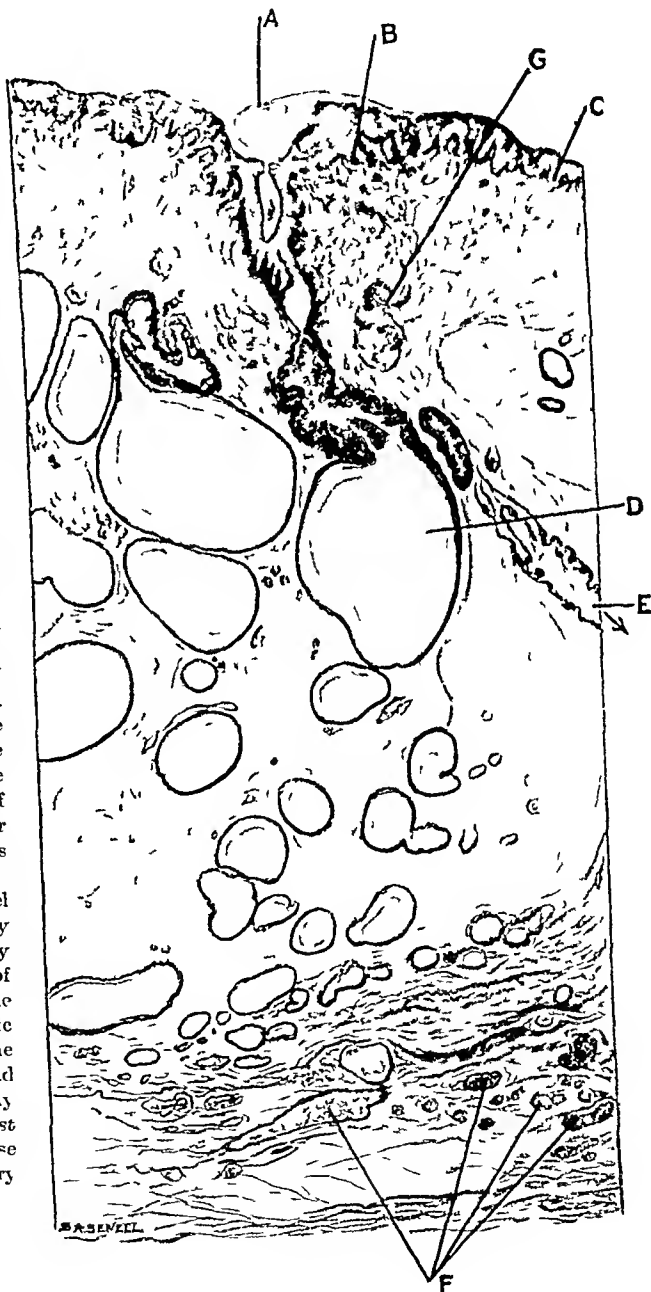
Fig 215—Whole section of a breast affected by Paget's disease of the nipple Female age 53 A and B mark the limits of the disease C points to the centre of the nipple and to a duct outlet destroyed by the disease this duct leading to the greatest amount of carcinoma found in the breast, D There were no lymphatic vessels containing carcinoma in the remains of the retracted nipple and areola E indicates the area seen under higher magnification in *Fig, 214*



Between all of these lesions and the subjacent elastica, connective-tissue hyperplasia has already taken place (*Fig 216, C*), and in the older regions of

the disease hyperplasia of the connective tissue can be seen occurring in the midst of the elastica and outside its boundaries in varying degrees (*Fig 216, B*) I regard these connective tissues as being purely secondary in character

FIG 216—Part of a whole section of a breast affected by Paget's disease of the nipple. Female, age 53, married. Elastica stained. The disease is affecting the whole of the nipple and most of the areola. This reproduction does not quite include its boundaries. *A* is a plugged duct outlet affected like the surface of the nipple with Paget's disease. The duct leading into it has been cut longitudinally and can be seen to be filled with carcinoma. Further, it is leading directly into a cyst (or dilated part of the duct) at *D*, to the upper part of which the carcinoma is limited. Lower down in the breast, carcinoma reappears in the same duct distribution at *F* in veins, branches of the duct, and lymphatic vessels. *G* is another duct which contains carcinoma, which, however, had not spread to the deeper part of the gland. *C* is the elastica, between which and the surface disease hyperplasia of the connective tissue is taking place at *B* where the process is older the hyperplasia of the connective tissue is no longer limited by the elastica and has spread beyond it. *E* is a longitudinal section of a blood vessel which extends to the periphery of the breast and was filled by blood clot in an early stage of organization. As I explain in the text the disease attacked a nipple of a proclinal breast in which the cysts encouraged the widespread distribution of the carcinoma. Many lymphatic vessels in the breast contained carcinoma. No disease could be discovered in the axillary glands.



The epithelial changes already described may in parts develop very slowly while in other parts comparatively large masses of closely-packed epithelial cells have formed as a result of their multiplication. In *Fig 217*

can be seen many mitotic figures. The masses of epithelial cells are never great enough to cause a fungating appearance on the diseased surface, which always remains clinically smooth level and firm somewhat resembling, in miniature, a hard lawn-tennis court. With the multiplication of the epithelial cells, invasion by them of deeper tissues undoubtedly occurs (*Fig 217*). At the margins of the growth there often exists a line of cuboidal or flattened elongated epithelial cells which suggest the appearance of an edge that is not invading deeper structures but as the cells are epithelial they form part of the invading mass. In the middle of the diseased part epithelial cells can be

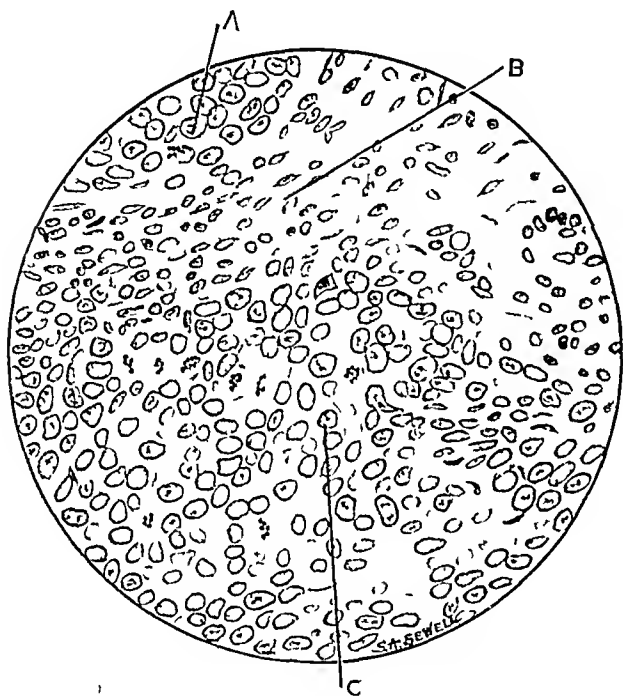


FIG 217—Reproduction under high power of a comparatively large collection of cells at one part of a nipple affected by Paget's disease. B is the connective tissue that is being invaded by the disease as seen at A and C. In the mass of diseased cells at A one mitosis is seen. In the mass of disease at C eight mitotic figures are seen.

seen including within them concentric bodies which compress the nuclei into semilunar shapes. The presence of these concentric cell inclusions is supposed by most to be typical to be observed only in Paget's disease of the nipple. Occasionally an epithelial cell nest can be seen. Although the disease begins in the pigment cell layers, the tumour that results from their multiplication is not pigmented. When Paget's disease of the nipple occurs elsewhere in the body it rarely, if ever, permeates lymphatic vessels, although the cells of the lesion invade deeper tissues. In this respect the condition resembles rodent ulcer. It would seem that when permeation occurs in the lymph

atic vessels which underlie a Paget's disease of the nipple the permeating carcinoma cells must be derived from a carcinoma in the breast. Retraction of the nipple is the cause of an apparent disappearance of that structure, when its real disappearance occurs, it is doubtless caused by the invasion of epithelial cells, the chronic infective process that accompanies it, and the atrophy of the musculature.

THE CARCINOMA IN THE BREAST

I have already stated that I have not yet been able to discover a Paget's disease of the nipple that was not associated with carcinoma in the breast.

I have no evidence to show that a proemial breast is more liable than

any other to be attacked by Paget's disease. I have evidence that when carcinoma attacks a proenual breast in which Paget's disease is present the spread of the carcinoma in the glandular elements is very extensive (*Fig 216*). My explanation of this fact is that the dilated cystic state of the ducts allows a free distribution of the agents that induce carcinoma. The fact that carcinoma in the breast is so commonly associated with Paget's disease of the nipple at once makes one suppose that there is a definite connection between them and indeed there must be. I propose to discuss what that connection is, but before doing so there are two facts to which I must draw attention. The first is that the associated carcinoma in the breast varies with the types of epithelial cells that are affected. For instance *Fig 194* shows a type of disease somewhat similar to Paget's disease

of the nipple, the only difference being an absence of the concentric bodies so typical of that condition. In the normal state the epithelium of this part of the duct is in the process of changing in type from squamous to columnar. The columnar type has not become definitely established. In the lower parts of the nipple the epithelium of the ducts is definitely columnar, and when these parts are attacked the carcinoma is a duct carcinoma (*Fig 207*). When the acini are affected, as they are at E in *Fig 205*, at A in *Fig 203*, and at D and E in *Fig 218*, the disease is not recognizable as a columnar-

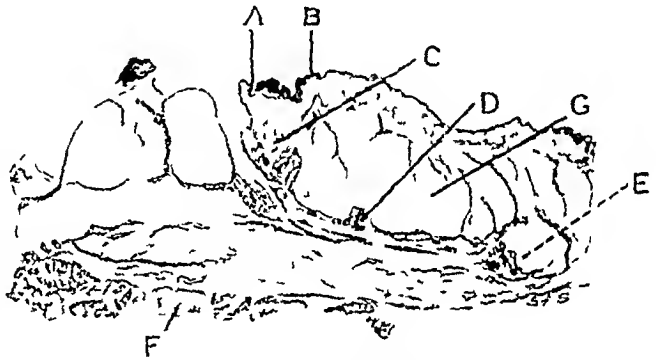


FIG 218—Whole section of breast affected by Paget's disease of the nipple. Female, age 51, married. A and B mark the limits of the disease, at C are branches of more than one duct that are filled with columnar celled carcinoma, at D is a small area of carcinoma that is infiltrating the surrounding connective tissue. The dotted line E points to another and similar focus of carcinoma in the gland that was discovered a section or two lower in the series. F is the pectoralis major. Lymphatic vessels were permeated by carcinoma cells. The lymphatic vessels of the nipple and areola were not thus permeated. G marks the part in the fat from which *Fig 219* is reproduced under high power. On reference to *Fig 219*, it will be seen that a nerve contains carcinoma and that the lymphatic vessels are permeated by carcinoma. The nipple, A and B is markedly retracted.

celled carcinoma. It is possible for four types of carcinoma to exist in the same breast, viz (1) Paget's disease of the nipple, (2) The somewhat similar disease in the upper duct, (3) Columnar-celled carcinoma and (4) Acinous carcinoma. They all occurred in the breast reproduced in *Fig 205*. Also *Fig 202* shows that in one breast there were Paget's disease of the nipple, a slightly altered and somewhat similar disease in the upper regions of two ducts, a large multinodular papilloma the precise nature of which is decidedly doubtful, and an acinous carcinoma. The other five breasts are equally interesting from this point of view.

The second fact is that the carcinoma in all parts of the breast is not always in direct continuity with the Paget's disease (*Fig 216*).

Induction of carcinoma in the subjacent breast could occur in one of three ways

1 The superficial tumour (Paget's disease of the nipple) may grow downwards, using the mammary ducts as its pathways, in the same manner as lymphatic vessels act as viaducts for carcinoma. In *Fig 194* an early implication of the upper part of a mammary duct has occurred. There is no normal epithelium lining this part of the duct. If this duct were acting merely as a pathway for a downward-growing tumour, a normal epithelial lining should be present especially in such an early stage. No such thing can be seen. Its appearances do more than contradict the possibility of a downward growth, they indicate that the epithelium which when normal lines the upper part of this duct, is now in the early state of primary disease. This leads to

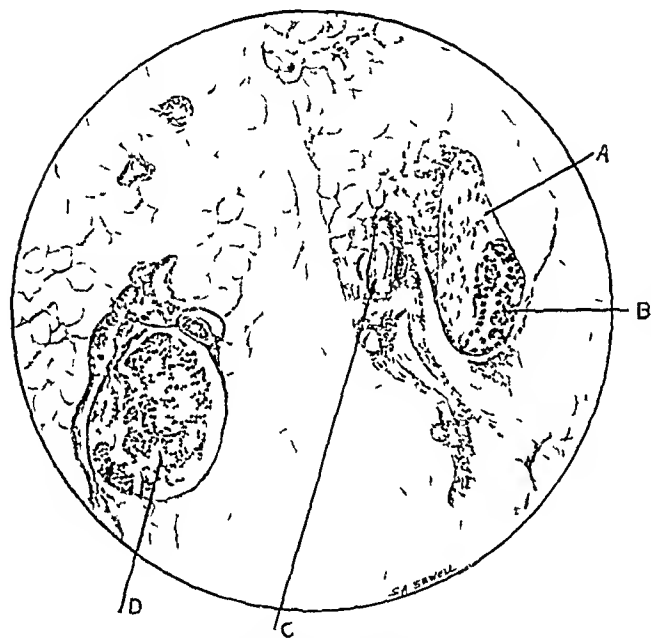


FIG 219.—A reproduction under high power of the part G in *Fig 218*. A is a nerve fibre in which there is a mass of carcinoma. B, the perivascular lymphatic vessels at C are permeated by carcinoma. at D is a large mass of carcinoma in transverse sections of lymphatic vessels.

another point. The carcinoma that affects parts of the breasts that are deeper than the upper duct region bears no resemblance to the carcinoma on the surface. The carcinoma that grows in the deeper parts of the breast does not look like Paget's disease of the nipple and has no concentric cell inclusions and by affecting lymphatic glands and the body generally shows that it may be much more malignant than that disease. If it were a downgrowth of a tumour, normal epithelial structures would be surrounding the tumour, but there are no signs of them. On the contrary, the normal structures have become carcinoma.

There must be something more than merely a downward growth of a tumour, because in *Fig 216* at D there is an abrupt solution in the continuity of the tumour process, which reappears in the terminations of the same duct at F. To explain this fact it would be necessary to invoke the aid of another possible factor described in the next paragraph.

2 It may be that portions of the disease upon the surface are detached and by means of transplantation become grafted in the deeper parts of the breast and grow there. In *Fig 194*, D, there is a clump of a dozen epithelial cells which look as though they might have been detached from a growth elsewhere and had then started to grow in their new situation. Assuming that this has occurred, it must be admitted that the graft was detached from the growth in the duct, and that growth is not identical with

that of the Paget's disease of the nipple Figs 203 206 207 209 215 216 218, and 220 show the same difference in character between carcinoma in the breast and Paget's disease on the surface On the whole the theories that a tumour in the breast is the same growth that has spread from the surface either by natural pathways or by transplantation cannot be accepted It is therefore necessary to propose in the next paragraph another interesting and more important explanation

3 The agents of mutation that induce Paget's disease of the nipple may also be concerned in the induction of the primary carcinoma in the epithelial cells of the breast, to which the agents of induction are distributed by means of the mammary ducts

There are a good many criticisms that can be adduced against this thesis For instance, why are not the sweat glands affected by carcinoma when Paget's disease of the nipple reaches the skin? I cannot discover evidence that they are Or if the agents of disease are capable of inducing a primary carcinoma of the breast, why cannot these same agents also induce Paget's disease of the nipple? If they could, the latter would be a common and not a rare disease Or when a breast carcinoma spreads to the skin why does it not induce a squamous epithelioma in the epidermis? Why is not the whole epithelium of the ducts and the acini all involved in primary carcinoma?

Figs 200, 202 205, 209, 215, 216, 218, and 220, in which the nipples are all affected with Paget's disease show that carcinoma mainly affects one duct although the degree of extension is different in each of the eight different breasts The sections show this clearly, but it must not be assumed that other ducts are not attacked, for in the specimens shown they are attacked, though to a less extent One reason for this disproportionate affection of one duct may be that its outlet was attacked by the disease at an earlier stage and that therefore the disease in it made greater progress This explanation does not appear to me to be complete There are probably other reasons concerned with more complicated factors connected with the biology of cells, I do not now propose to enter into these problems further than to state that they are suggested by recent observations made by Dr A J Murray in which he mentions the difficulty of inducing a fresh area of tail carcinoma in a mouse that is already suffering from that disease

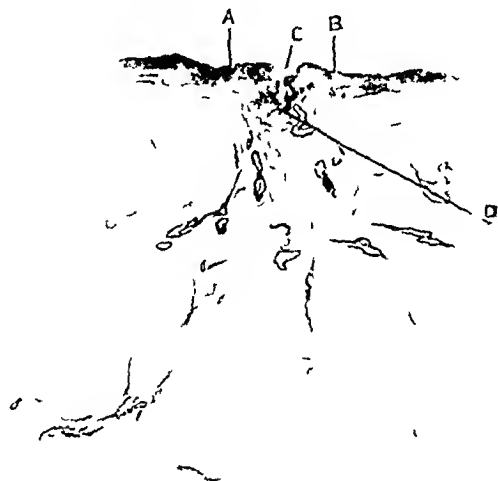


FIG 220.—Part of a whole section of a breast affected by Paget's disease. Female age 45, married. A and B mark the limits of the disease, C is the duct outlet mainly affected, leading to a duct carcinoma the lowest limit of which is at D which also represents the lowest limit at which carcinoma can be discovered in this breast. Two more ducts are affected in lesser degree near the diseased surface epithelium. The lymphatic glands in the axilla were free from disease, lymphatic vessels adjacent to D were filled with carcinoma cells.

However cogent the above criticisms appear to be there are important reasons for placing limits to their application. For instance, carcinoma can be multicentric in origin: this occurs in Paget's disease of the nipple, in rodent ulcer, in squamous epithelioma, and before I knew of Dr Archibald Leitch's impressive observation², I published reasons in this JOURNAL for stating that it also occurs in the carcinoma in breast epithelium. Dr A. J. Murray's observation on tail carcinoma to which I have already alluded offers some explanation why multicentric origin does not occur more extensively when once it begins, and why *there may be a limit to the number of cells attacked in the carcinoma process in the breast where Paget's disease of the nipple is also present*. At the same time Dr Murray's observation could be urged against the possibility of a multicentric origin of carcinoma. As it is known that multicentric origin of carcinoma does occur, Dr Murray's perfectly accurate observation must have limits to its application. The work of Mr A. J. Walton³ and Dr A. H. Drew⁴ in this country, and of Canel in America, offers important evidence to explain not only that multicentric origin of carcinoma occurs in the same type of epithelium but also that primary carcinoma could be induced in other epithelial cells not strictly of the same type. Further investigations on similar lines are likely to demonstrate how the agents that induce Paget's disease of the nipple are concerned in the induction of the associated carcinoma in the breast.

PATHOLOGICAL CHANGES THAT ARE NOT MALIGNANT

I must allude to changes other than carcinoma that can be seen in the breasts suffering from Paget's disease of the nipple. No doubt many of them were in existence before that disease began: for instance desquamative hyperplasia of epithelium which led to the formation of cysts (*Fig 216*), intra-elastica, elastica, and extra-elastica hyperplasia of connective tissue. There are other changes that are a direct result of Paget's disease of the nipple, such as the irritative hyperplasia of connective tissue that occurs first of all between the elastica and the superficial disease (*Fig 216*) and then extends into and beyond the elastica. A remarkable fact about this hyperplasia is the presence of a great collection of plasma cells. Desquamative hyperplasia of epithelium of ducts and acini is marked in many parts, especially below the carcinoma in the gland. In *Fig 204* is a multinodular papilloma⁵ which is probably a result of the general irritation of the duct in which it is growing. In one or two breasts long tracts of blood-vessels have become completely

* In "A Further Contribution to the Study of Cysts and Papillomata of the Breast", published in THE BRITISH JOURNAL OF SURGERY, 1921, Vol. IX, No. 34, I pointed out how common it is for a papilloma to originate in a duct ampulla. Professor Hobday, F.R.C.V.S., informs me that in a cow's udder there is a sinus in the duct which corresponds in position to the ampulla of a human mammary duct and that in this sinus papillomata are also common. This fact supports the contention I adduced in my paper that papillomata are due to a local irritation that is applied directly to the epithelium and that they are not due to any cause acting outside the duct. I also made a special point of stating that the irritant might gain an entrance by means of the opening of the duct on the surface of the nipple, or it might be contained in the altered or unaltered secretions of the breast.

blocked by semi-organized thrombi (*Fig 216*) In some the mammary ducts themselves appear filled with semi-organized tissue that completely blocks their lumens (*Fig 204*) The tissue may be the result of hemorrhage within the duct or an intra-elastica hyperplasia I am not sure which for no epithelial elements remain to give a hint as to the situation of this tissue

PATHOLOGICAL CHANGES THAT RESEMBLE PAGET'S DISEASE OF THE NIPPLE

There are two conditions which resemble in different ways Paget's disease of the nipple, but are totally different from it and from each other The first has a microscopical and not a clinical resemblance In the second condition the resemblance is clinical and not microscopical

In the first, the cells of an underlying carcinoma have grown into the deeper epithelial cells of the surface epithelium of the nipple (*Fig 197*) Usually in this condition the surface of the nipple is so puckered that it resembles a cluster of small warts The nipple is fixed retracted, and its surface is hard The condition is much more common than is generally supposed and is often mistaken for Paget's disease when examined microscopically Clinically it does not in the least resemble it

In the second condition, the surface epithelium of the nipple has been shed and the superficial underlying carcinoma has been exposed and resembles the clinical appearance of a typical Paget's disease of the nipple Microscopical sections of this condition (*Figs 198 and 199*) show that the underlying carcinoma of duct origin is exposed by shedding of the surface epithelium except at the margins where it is intact and in no way resemble in appearance the changes that occur in Paget's disease Clinically the condition does resemble it The surface is red, dry, and may be covered with fine white scales The edges are hard The scales when examined microscopically do not show the concentric bodies included within epithelial cells which are generally supposed to be so typical of Paget's disease

The practical result of this paper is to enforce the principle which is already accepted except by a few, that a breast suffering from Paget's disease of the nipple should be subjected to a most complete operation for its removal, together with the lymphatic glands in the axilla

SUMMARY

My conception of what is mainly occurring is as follows —

- 1 Paget's disease of the nipple is carcinoma
- 2 Carcinoma in the breast, with which Paget's disease of the nipple is usually associated is a primary carcinoma of the breast epithelium
- 3 The connection between (1) and (2) is that the agent of irritation which is inducing Paget's disease is also concerned in inducing primary carcinoma in the epithelial cells of the underlying breast, which is reached by means of the mammary ducts

I have to thank many who have sent me material, often at great trouble to themselves. My gratitude is especially due to Mr F F Burghard, Mr Raymond Johnson, Mr Percy Legg, Mr Arthur Edmunds, Mr Zachary Cope, Dr Gilbert Charsley, and Mr Harold Burrows. While writing this article I have been indebted to Sir Nestor Thaird for several suggestions upon the arrangement and presentation of my observations, and I have had the privilege of consulting Dr Arthur Whitfield on many vital points.

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ARTHROPLASTY.

A CRITICAL SUMMARY OF THE DISCUSSION UPON THIS SUBJECT, AT A MEETING
OF THE SIXTH CONGRESS OF THE INTERNATIONAL SOCIETY OF SURGERY
HELD IN LONDON, ON JULY 18, 1923
BY ALAN H TODD, LONDON

The majority of the really epoch-making operations of surgery have passed through a certain number of phases in their life-history. Following upon their invention, and first description in surgical literature, they have endured a more or less strenuous experimental or evolutionary phase, during which they have been vigorously assailed by the exponents of older methods, and have had to struggle hard for their existence. Failures and partial failures result, at this stage, from imperfect technique and immature selection of cases, and unless the proposed operation has vigorous champions, or holds out particularly alluring prospects in the event of its developing into a success, there is a great danger of its being dropped at this stage and allowed to join that vast majority of "hopes blasted and things that might have been." A still greater danger, perhaps, is a sort of tidal wave of enthusiasm, in which the operation is adopted far and wide, performed indiscriminately by all sorts of surgeons in all sorts of cases (many of them unsuitable), and is finally drowned by the number of disappointing results that appear, and the sane judgements that prevail when the first wave of enthusiasm has passed. An operation, however, that is able to weather this storm is usually a good one, and its later history is less eventful, and the results that can be obtained by its employment become improved, and the results that are appreciated, it takes its place, in fact, in the science and art of surgery.

Arthroplasty is still passing through the period of 'storm and stress', though there was a general feeling of optimism concerning the operation amongst the large body of surgeons who crowded the Baines Hall upon the occasion when the discussion was held. There could be no doubt, after hearing what was said, and seeing the results that were presented, that arthroplasty had come to stay, that it was a definite advance upon anything that had preceded it, in certain cases, and that it had a great future before it. But many of the speakers, and especially those who were its most enthusiastic supporters, were careful to emphasize that the operation was not one for the inexperienced surgeon to attempt, that it was, and always must be, a method to be adopted only by those experienced in the surgery of bones and joints, that it was still in the experimental stage, though it had established itself as possessing a definite sphere of usefulness, and very much depended upon sound judgement and a wise technique, and lastly that very much still remained to be done to define the indications and contra-indications for the operation, to extend and improve its field of usefulness, and to correlate its results

Strictly speaking the occasion was not so much a discussion as a presentation of a series of interim reports by a number of workers specially interested in this class of surgery. They served to show what had been achieved up to the present time to define our present position with regard to arthroplasty, and to indicate the lines upon which future work ought to proceed. There is always a risk, at a large meeting of this kind that the discussion may become abortive through being diffuse and ill-defined but fortunately upon this occasion this danger was avoided partly because the field for discussion is still fairly narrow (the majority of the operations having been performed upon the knee elbow and hip) and partly because Mr Hey Groves who introduced the subject, indicated the lines upon which discussion would be most profitable.

Arthroplasty was *defined* as an operative procedure upon an ankylosed joint having for its object the restoration of mobility and several speakers attempted, somewhat unsuccessfully to draw a sharp distinction between arthroplasty and excision. It was emphasized that stability as well as mobility must result from an arthroplasty, and that any operation which failed to satisfy these two conditions was unworthy the name of arthroplasty. MacAusland, in laying stress upon this point, quoted John B. Murphy's saying that "arthroplasty to be functional must be stable and excision of joints results always in flail joints", and added, "A flail joint cannot be considered a proper result from a plastic operation. Excision has no place in the surgery of weight-bearing joints save to obtain ankylosis nor would it be used in non-weight-bearing joints if it were not that flail joints may be stabilized by means of light apparatus." The French speakers and especially Santy and Leriche—representing the views of Ollier and his followers in Lyons—contended that in many cases the subcapsular excisions of Ollier gave results that were as good, functionally as those of the typical arthroplasty, and it was unfortunate that so little attention was bestowed upon the very temperate and modest presentation of their results which these workers brought forward. Their summary was delivered in rapid French and time was short, so that it failed to arouse the interest and discussion which were due it, but one felt at the conclusion of the session that, whilst one side had undoubtedly set forth a very strong case, and had indeed, upon some points, quite carried the day yet there was much that was interesting and instructive that should have been heard upon the other side. Some account of their results, however, is presented below.

The *indications* for the operation were discussed from several points of view. It was generally agreed that sound bony ankylosis resulting from bygone pyæmia presented the most favourable field for operation as far as the bacteriology was concerned. MacAusland mentioned that streptococcus, pneumococcus, and gonococcus gave the most rapid ankyloses, with the result that arthroplasty could, as a rule be performed earlier after these infections than after others. Poly-arthritic conditions, in which infection persisted in a smouldering condition year after year, were regarded as less favourable, and bony ankyloses were mentioned as being, in general much more easily and satisfactorily treated by arthroplasty than were fibrous varieties. There was some difference of opinion as regards tuberculous cases, and some speakers

mentioned successful cases of arthroplasty after bygone tubercle. The consensus of opinion, however, was that in an ankylosis known to be due to the tubercle bacillus, arthroplasty was fraught with risk at any date and was in consequence contra-indicated. Putti and MacAusland both expressed themselves as being definitely averse from operating in known tuberculous cases.

No definite time-limit was laid down after which arthroplasty could be properly undertaken, each case had to be considered upon its merits. It was recognized as a general principle that the longer the time-interval between the acute infection and the plastic operation, the greater would be the chances of success, and there appeared to be a widespread feeling that the risk of operating a year or two years after the initial acute infection was so small as to be justifiably taken. It was stated also, and demonstrated by the patients' photographs and statistics shown, that it was not necessary to wait until all residual infection of the soft parts around the joint had disappeared, indeed, it appeared from the histological evidence available that to do so would be to wait for ever. All that was necessary, in practice, was to wait a reasonable time until the clinical signs of infection had subsided, and attempts to provoke fresh exacerbations of infection by means of hot-baths, massive doses of autogenous pyogenic vaccine, and the like had failed. Elmslie made the admirable observation, at this stage that the surgeon was confronted with two questions—namely, what to do and when to do it—of which the latter was the more difficult problem.

The condition of the soft parts has to be taken into account quite as much as that of the bones themselves, this was a point that was made by several speakers. In cases of ankylosis following war injuries, in particular, the associated destruction of skin, muscles, vessels, or nerves, might be so great as to render operation difficult or even impossible, whilst in other instances preliminary operations might be required, such as pedicled-flap grafting, in order to provide a satisfactory nutrition and covering for the proposed field of arthroplasty. Gross deformity, again, would call for operative correction in many cases before the arthroplasty itself was undertaken, for example, a hip ankylosed in flexion and adduction would demand preliminary correction, unless great difficulty was to be encountered at the chief operation.

Some difference of opinion was manifested, naturally, on the question of the surgical and anatomical conditions which justify the performance of an arthroplasty. Its more enthusiastic advocates would have performed the operation where others would have been conservative. The opinions of MacAusland, however, may be accepted as a fair summary of the views of those who are best qualified by their personal study of results to judge of this question. He says “(1) Two stiff hips will indicate arthroplasty on one hip or possibly both. (2) Two stiff elbows will present the same indication. (3) Two stiff knees will present a definite indication for an arthroplasty on one side at least. (4) Combinations of hips and knees in one individual—a condition not infrequently seen in multiple arthritis—is a very definite indication for attempting to mobilize one or more joints.”

Putti, whose experience of arthroplasty is greater than that of any other one surgeon, laid especial stress upon the due consideration of the tempera-

mental and social aspects of every case. He more than any other speaker emphasized the need for complete and willing co-operation upon the part of the patient, the willingness to submit to a certain amount of pain in the early days of the convalescence, the painstaking after-treatment and so on. He also laid stress upon the need for due consideration of the economic aspect of every case, the age and occupation of the patient were often determining factors, whilst it was futile to attempt an arthroplasty unless the patient possessed the time and the means to undergo the necessary after-treatment.

The occupational question is, of course, a relative and a labile one, and so it must always remain. At the meeting no decision was reached upon this point. As conditions of surgery change the profession's verdict upon the operation must change also. For example, it has long been recognized and taught that a good strong bony ankylosis of the elbow in good position is preferable in the case of a working man to a more or less unstable excision. That is undoubtedly true. But that teaching does not negate the possibility of a thoroughly stable, useful and reliable excision of the elbow, and cases of this kind are in existence and on record. It cannot be dogmatically laid down therefore that arthroplasty or excision should never be attempted in the case of a working man's ankylosed elbow, it can only be said that in a majority of cases at the present day the operation is not indicated. It is only by attempting these operations however that improvement will be attained, and as long as the development of the operation is left in the hands of able men it will no doubt be brought much nearer perfection than it has yet attained and many of the verdicts of to-day will need revision in due course. How much has already been achieved was obvious to all those present at the meeting who could recall the results that were available say, ten years ago. The world owes a great debt of gratitude to those few courageous determined men who have gone on developing the operation of arthroplasty in the face sometimes of great discouragement, until they have been able to place on record the remarkable successes that were revealed at the Congress of 1923.

If the occupational question is a variable one, at least the temperamental one is not. Unless the patient really needs the use of a movable joint, the operation should not be performed. The operation is a considerable one in the case of the larger joints and one that involves an appreciable amount of shock and of pain also in the early part of the convalescence, and unless the patient is prepared to undergo these for the sake of what he will gain the success of the operation will be jeopardized. The after-treatment also is of the utmost importance, the patient must be willing and anxious to carry it all out patiently and assiduously, or else disappointment may ensue. For this reason, amongst others, arthroplasty is contra-indicated in most cases of rheumatoid arthritis, the patients are so often enfeebled, temperamentally as well as physically by their prolonged sepsis and sufferings, that they will not endure the necessary post-operative régime, moreover, as Elmslie pointed out, the operation uniformly fails in this condition owing to the reappearance of the disease in every new joint made.

On the other hand it must be remembered that there are cases in which the presence of constant pain is one of the main indications for operative

treatment in chronic arthritis, if monarticular, and some form of arthroplasty is perfectly permissible, in well-selected cases, in preference to arthrodiesis

The discussion was introduced by *HEV GROVES* of Bristol whose paper is given on page 231

The next speaker was *PUTTI*, of Bologna, who dealt mainly with the technique of the operation of arthroplasty, which he illustrated by means of a long and very complete cinematographic record of an operation upon an ankylosed knee. Every stage of the operation was clearly shown, from the arrival of the patient in the operating-theatre, up to the application of the splint and his return to bed, where a weight-extension was applied. The steps of the operation need not be detailed here, for it was described in full in the *BRITISH JOURNAL OF SURGERY*, 1923, XI, 144, under the heading "Surgical Clinics at Home and Abroad"

Following upon his demonstration of the operation, Professor *Putti* described and illustrated his after-treatment. He advises active movement of the 'knee' twelve days after operation, active and passive movements twenty-five days after operation, and a long course of hot-air baths. Massage and gymnastic and walking exercises follow in due course, and the cinematograph was again employed to show patients walking up and down slopes and stairs, walking and running on level ground, turning sharply round, jumping, and so on. Five patients were also demonstrated who had come from various parts of Italy especially for the meeting, and those present had an opportunity of seeing how well they could walk, how slight was their limp, and how stable were their neo-arthroses. All were cases of arthroplasty of the knee following military wounds, and several were the patients whose cases were recorded in the article in the *BRITISH JOURNAL OF SURGERY* referred to above.

Professor *Putti's* demonstration was exceedingly clear and masterly, and was without any question the outstanding feature of the discussion, it was a great personal triumph as well as a most lucid and convincing exposition of the matter in question. The conclusions at which this surgeon had arrived were based, he said, upon the experience of 142 arthroplasties.

MacAusland, of Boston, who followed, gave a detailed description of his technique as employed in arthroplasties of the elbow, knee, hip, jaw, and great-toe joint. The details were explained by the aid of a cinematograph film, and a large series of photographs and radiograms was also employed to demonstrate the condition of patients before and after operation. The technique resembled that used by *Putti* in its broad principles—namely the free exposure of the joint, the division of the ankylosis as far as possible in the original line of the joint-cavity, the remodelling of the newly-cut surfaces in imitation of their original form, and the covering of them with a free transplant of fascia lata, followed by the complete suturing and closure of the wound. In the printed report of his speech which *MacAusland* had prepared for his audience each of these operations was illustrated at every important stage by means of a photograph.

Leriche of Lyons spoke next, in French, and gave a short but very instructive paper by *Santy*, embodying the views of the *Ollier* school upon the subject of the mobilization of ankylosed joints. It was stated that arthroplasty, properly so called, had made so little headway in France up

to the present time, that it was hardly possible to make a useful comparison between the results of that operation and those of the 'mobilizing resections' that had been described by Ollier in 1869, and had been extensively practised ever since. Arthroplasties, these authors said, had been carried out by them in so few examples that any comparison must be made by the standard of recorded cases, and not by those of their own operation-results. Under these circumstances, they felt that their best plan was to present a statement of the results they had achieved by Ollier's methods, and leave it to others to draw a comparison between them and those due to arthroplasty.

They laid great stress upon the fact that 'resections mobilisatrices' properly carried out in accordance with Ollier's instructions, were capable of producing a neo-arthritis that was both mobile and stable. They insisted, moreover, that this was no new type of operation, but one that had been successfully performed for a number of years and that merited careful consideration in consequence. It was important that sufficient bone should be removed to allow of free play between the new articular surfaces, and they said that whereas it was often stated that the main objection to resections was the risk of flail joint, the real risk was that of the recurrence of ankylosis, in consequence of insufficient removal of bone. (Thus, it may be observed, was taught many years ago in our own country by Sir Henry Howes.) Another point which they emphasized was the necessity of removing any portion of the joint-capsule or other structure that might be supposed to contain ossific structures—in other words, cells which, awakened to activity by the stimulus of the operation, might proceed to form bone, and so impair the functional result.

Santy then proceeded to record his views upon the comparative value of arthroplasty and mobilizing resection. In the case of the shoulder, he thought that operation of any kind was seldom required, owing to the excellent range of supplementary movement that was afforded by the mobility of the scapula. He considered, however, that there were two conditions in which operation was indicated, namely: (1) Ankylosis of the shoulder-joint in which the upper limb was fixed in a position of internal rotation, so that flexion of the elbow was rendered difficult or impossible, in such cases cervical osteotomy would correct the malposition, but excision of the shoulder-joint possessed the advantage of improving the movement of the joint proper at the same time. (2) Ankylosis of the shoulder complicated by fixation of the scapula to the chest-wall, a condition that is not infrequently found as a sequela of military wounds and that lends itself to successful treatment, provided that the deltoid survives. Santy and Leiche, having studied the recorded results of arthroplasty of the shoulder, consider that a mobilizing resection, properly carried out, yields equally good results.

The elbow they said, was a specially favourable site for the operation, and both the indications for the operation, and the details of its technique, had been completely worked out. They maintained that a well-executed resection would restore mobility, combined with stability, both to the elbow-joint and to the superior radio-ulnar joint. The special points in technique upon which they laid emphasis were: (1) The removal, on an average, of at least 5 cm. of bone, the section of the humerus being made across the widest part of the condyles, and that of the forearm being made at the level of the

neck of the radius, distal to the coronoid process (2) The removal of the head of the radius is essential to the restoration of pronation and supination (3) The ablation of every scrap of more or less ossified or ossifiable capsule so as to remove all risk of post-operative bone-proliferation in this structure (4) Careful conservation of the biceps If there is any risk of impairing its power through lacerating its tendon during blunt dissection with the rugine a temporary division of the olecranon process should be performed (5) Finally, the post-operative treatment is of the utmost importance, complete rest in a plaster splint is the best method of guarding against the risk of activating any tendency to bone-proliferation in the residual structures of the joint

At the wrist they consider arthroplasty can rarely be required, but in those exceptional cases where some operation is indicated, excision gives an equally good result

In the case of the hip, they think that operation is seldom necessary In this joint, more than any other, it is absolutely imperative that an operation if performed at all, shall result in stability as well as mobility They maintain that where there is considerable destruction of bone, and consequent deformity excision should be employed, whilst arthroplasty would be preferable in the remaining cases (Tuberculous cases, however, form an exception, and the site of the bygone disease should not itself be attacked, some form of transeervical or subtrochanteric osteotomy should be preferred) Santy pointed out very properly that in many cases where there has been a considerable destruction of bone resulting from the acute infection that produced the ankylosis, the distinction between arthroplasty and excision is almost a verbal one a considerable amount of bone has to be cut away at the site of ankylosis in order to ensure mobility afterwards, and the anatomical condition left after the operation is tantamount to the result of an ordinary formal excision

In the case of the knee these surgeons freely agreed that arthroplasty had no equal

Snr William Macewen agreed with the last speakers that flail joint was never the result of an excision of a joint, provided that the excision was intra-capsular He commented upon the use of fascia as a limiting membrane, analogous in its action to that of the bone-limiting periosteum, and said he thought that the somewhat imperfect range of movement shown in some of the cases demonstrated (photographically) by preceding speakers was due to insufficient removal of bone

Flimsle who followed laid special emphasis upon the importance of relief of pain as one of the indications for arthroplasty, apart from any question of restoration of movement He considered that in the case of the lower extremity arthrodiesis was preferable to arthroplasty which was only indicated in examples of multiple ankyloses not due to rheumatoid arthritis He had recently completed a survey of all the crippled children attending the special schools for the physically defective which are maintained by the London County Council and had been very much impressed by the satisfactory functional results that were given by good arthrodyses in these cases They were much better and less troublesome than those of arthroplasty

One boy, for example who had an ankylosis of the hip could walk ten or twelve miles a day and this was not an isolated instance. Incidentally, he mentioned that the radio-ulnar joint should not be attacked at the same time as the elbow-joint proper in an excision of the elbow.

Sir William de Coney Wheeler, of Dublin said that arthroplasty of the shoulder was no better than excision provided that the deltoid was good and the scapula free. For working men arthrodesis in good position was preferable. He described a successful case of arthroplasty of both knees for ankylosis, and emphasized the importance of preventing pain during the after-treatment, pain resulted in spasm of the thigh muscles and this in turn drew the newly-fashioned joint-surfaces strongly into contact, and led to atrophy of the fascial transplant and re-ankylosis. He thought the main point in order that this pain might be avoided was the free removal of the joint-capsule because of the large number of sensory nerves contained in it. The work of Murphy and others had shown that capsule was very easily regenerated, and that there need be no hesitation in removing it freely.

Jurasz of Prague, claimed that no arthroplasty would ever make a normal joint. He suggested that it was wiser to take the fascial transplant, in the case of arthroplasty of the knee, from the opposite leg because the ilio-tibial band was an important factor in stabilizing the knee-joint, and as such ought not to be damaged on the side of the main operation. (It may be remarked that to take the transplant from the opposite limb is advantageous for another reason namely, that with the tommyket in place on the side of the ankylosis there is often hardly enough room to enable one to cut a sufficiently large and strong transplant, and the thigh-incision is apt to encroach in consequence upon the area of the arthroplasty, if the flap is taken from the opposite limb it can be cut of any desired size and can be taken from the upper part of the thigh, where it is much stronger than it is further down.)

NOTE—Since the above was written, the writer has received a letter from Dr. Lenehe in which he states the points that he would have made had he had time to present his own conclusions in addition to those of Dr. Santy, whose paper he read. He says that his experience consists of 15 subcapsular resections of the elbow by Ollier's method, 3 arthroplasties of the knee by Putti's method, and 2 resections of the hip. His opinion is that in the case of the elbow arthroplasty, with the interposition of a fascial flap, gives results which are no better than those of a good operation of the Ollier type. Movement, perhaps, is more easily restored after arthroplasty but lateral stability is greater after the Ollier operation, and the ultimate range of movement is no less. He considers that arthroplasty is not an advance upon the older methods, except in the case of the lower extremity but there the advance is 'immense'. After seeing Putti operate and examining some of his patients he thinks that his method of arthroplasty constitutes one of the most striking achievements of modern surgery, so much so that the time is coming when an ankylosis of the knee, in good position, will no longer be regarded as a sufficiently good result, and the surgeon will feel himself justified in seeking to improve upon it in selected cases.

SOME RESULTS OF NERVE ANASTOMOSIS *

BY SIR CHARLES BALLANCE, LONDON

I PRELIMINARY REMARKS LATERAL IMPLANTATION OF THE TWO ENDS OF A DIVIDED NERVE INTO A NEIGHBOURING UNINJURED NERVE

In what one of the reasons which militate against successful operation for injury of a peripheral nerve is the difficulty experienced in deciding by visual inspection the extent to which a nerve has been damaged beyond the obvious injury. Sepsis and concussion are the two factors which blind the eyes of the surgeon. What sepsis, as we all know, may destroy the nerve physiologically for a long distance. As well as this kind of damage, a high-velocity projectile passing through a limb, and severing an important nerve, possesses, besides its cutting action, an explosive influence which—though in the case of a modern bullet the wounds of entrance and exit heal by first intention, and there is no sepsis—leaves a part of the nerve dead above and below the site of division: its living cells are destroyed by the concussion. Moreover, the tendency of the operator to freshen the ends of the nerve by only cutting away a small piece of tissue from each end, especially when there is a difficulty in getting the two ends together for end-to-end anastomosis, is also a cause of failure to get the best result. If lateral implantation of the two ends into an uninjured near-by nerve can be shown to be successful, there will no longer be any need to be afraid of generous pruning of the ends of the divided nerve.

In experimental work, the finest non-dyed arterial silk with a fine straight needle (Vau Hoin) have been employed. The advice to pass the suture only through the perineurium when dealing with tiny nerves such as the descendens noni or recurrent laryngeal of a small monkey, is an unattainable counsel of perfection. In some cases the suture material itself is only a little smaller than the nerve to be sutured. The result appears the same wherever this fine suture and needle pass: union takes place. More than one suture is unnecessary: approximation of the divided ends of the nerve alone is required. Cargile membrane being a dead tissue, has not been used. When the bed in which the point of suture lies is unsatisfactory the nerve is wrapped round with a slip of muscle or a piece of living fascia. The ends of nerves should always be freshened with a sharp knife, a blunt knife or the use of scissors causes contusion beyond the line of section.

Many opportunities occur in what of treating cases in which portions of one

* The patients and animals referred to in this paper were demonstrated to members of the International Society of Surgery on July 19, 1923, at the National Research Institute, Hampstead, by kind permission of the Medical Research Council, with the valued assistance of Dr. Dile. The researches on which the demonstration is based were made possible by a grant from and the great facilities offered by, the Medical Research Council.

of the great nerves of a limb have been destroyed. No surgeon would perform any operation but an end-to-end anastomosis when this is by any means possible. What method then should the surgeon employ in his endeavour to restore nerve function when end-to-end anastomosis is impossible? The common plan in the past has been either to fashion a flap from the upper segment of the nerve which can then be turned down to fill the gap, or to use some form of nerve-graft, either taken from another nerve of the patient (as for example the internal cutaneous or radial of the forearm) or a piece of human nerve preserved in alcohol or some other fluid, or to obtain a piece of living nerve from some other animal and fix it in the gap between the upper and lower ends of the divided nerve. If a living human nerve is employed as an auto-transplant some part of it will be absorbed and some of the cells will live just as happens when the auto-transplant, for other operation reasons is of bone. Other grafts of dead tissue or of living tissue heterogenous to the tissues in which it is implanted are absorbed completely, and remain only temporarily as a scaffolding for the invading neurolemma cells whose function it is to bridge the gap. The graft then must be an auto-transplant if any part of it is to live and no transplant can compare with the undamaged living portion of a nerve, between the two ends of another nerve fixed to it by lateral implantation. It is of great interest to note that the length of nerve between the lateral implantations increases in size as function returns in the distal part of the limb. The microscopical appearances and conditions found after lateral implantation—and especially the nature and cause of the thickening of the nerve between the lateral implantations—will be reported on a subsequent occasion.

During the South African War twenty-five years ago I had several opportunities of treating cases in which lengthy portions of important peripheral nerves had been destroyed. A patriotic butcher, living not far from my house was willing at any time to kill (without reward) a bullock or a sheep so that I might remove the sciatic nerve warm and living from the animal and employ it for bridging a wide gap between the ends of the divided nerve in a soldier. Over 6 inches of the great sciatic of a bullock was placed between the divided and widely separated ends of the great sciatic of a soldier, and the great sciatic of the sheep was used to fill gaps in smaller nerves such as the median and the ulnar. Thus all these cases were treated by heterogenous grafts a method which though giving in certain cases good results belongs now to the history of the evolution of surgical practice in the treatment of peripheral-nerve injuries. The difficulty of treating a great sciatic nerve a large portion of which has been shot away must always be considerable, but the plan adopted by Mr Joyce, of Reading (see a thoughtful paper by him in *THE BRITISH JOURNAL OF SURGERY* 1919, vi 418) was admirable. The gap in the great sciatic was bridged by three auto-transplants taken from the radial nerve of the forearm. Seeing the size of the great sciatic nerve, the only valid criticism is why not six auto-transplants instead of three?

The following brief notes give the story of the early stages of recovery in a case in which the physiological continuity of the great sciatic nerve was entirely interrupted in the upper part of the thigh.

SOME RESULTS OF NERVE ANASTOMOSIS 329

A man age 24 suffered from severe hæmorrhage after tooth extraction. He was admitted to a hospital in London. An injection of a solution of calcium chloride was given in the lower part of the buttock. Subsequently it was found that the patient was totally paralysed below the site of injection.

SENSATION — *Five months after the injection* Sensation had returned to a point a little below the knee.

Eleven months and two weeks after the injection Sensation (cotton-wool and pin pricks) had returned on the inner side of the leg to as far as just below the internal malleolus, but on the outer side sensation had not returned beyond a line three inches above the external malleolus. The sole of the foot, the dorsum, and the toes were without skin sensibility.

THE MUSCLES — *Six months after the injection* Some voluntary power in flexors of ankle.

Eleven months and two weeks after injection Some atrophy of muscles of leg and foot. Strong voluntary flexion of ankle by calf muscles. Doubtful voluntary extension of ankle but when the patient makes an effort of extension, the extensors in the upper part of the leg harden and patient says he feels a tingling down them as far as the toes. The toes are motionless. No voluntary movement of any of the intrinsic muscles of the foot. There is no response to the faradic current in the anterior group of muscles, in the peroneal group, or in any of the posterior tibial or calf muscles.

During the early part of January 1921, while on an official visit to Cairo, I performed in each of three large monkeys a double lateral nerve implantation, with the assistance of my friend Mr. Dolbey, Surgeon to the Kasi-el-Ain Hospital. The details of the experiments are as follows —

A Black-faced Soudanese monkey — The median nerve in the forearm was implanted in two places 3 cm. apart into the side of the ulnar nerve.

B Black-faced Soudanese monkey — The musculospiral nerve in the arm was implanted in two places $6\frac{1}{2}$ cm. apart, into the side of the median.

C Abyssinian trotting monkey — The external popliteal nerve was implanted in two places, $3\frac{1}{2}$ cm. apart into the side of the internal popliteal nerve.

In each operation the implanted nerve was fixed by two sutures to a longitudinal incision in the normal nerve. In these monkeys the nerves were large, and the operations were easy of accomplishment.

Professor Wilson, the professor of physiology and Professor Denny, the professor of anatomy, kindly took much interest in these experiments. Professor Wilson wrote to me about two and a half months after the experiments had been done that "although there is still weakness and some wasting there is almost complete recovery of motor power in the operated limb of all three monkeys."

Monkey A "has complete use of the hand and fingers using however the sound hand by preference."

Monkey B "has still indication of dropped wrist. The hand can be slightly extended and supination is possible. In walking the hand is placed flat on the ground and indeed the hand is slightly extended preparatory to touching the ground."

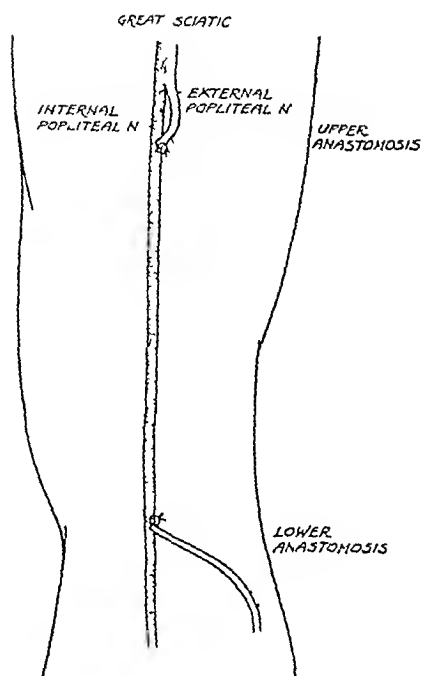


FIG 221—Double implantation of external popliteal nerve into internal popliteal

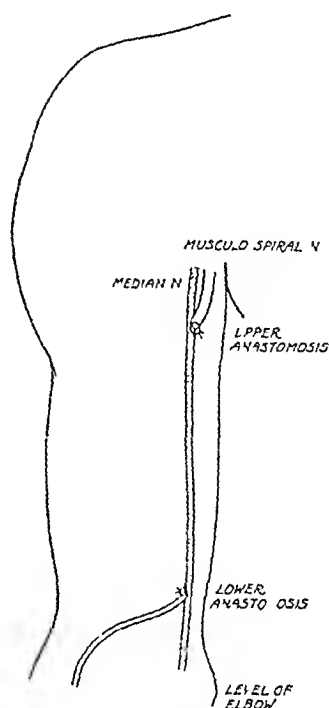


FIG 222—Double implantation of musculo spiral nerve into median

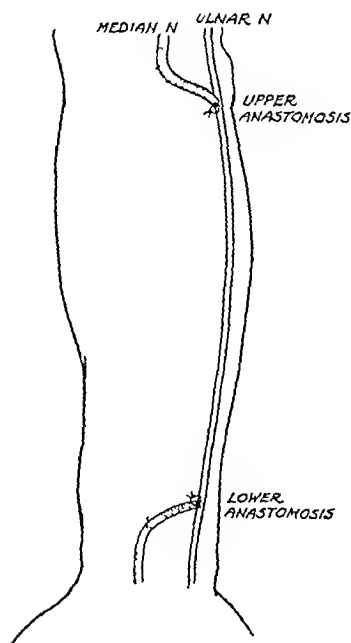


FIG 223—Double implantation of median nerve into ulnar

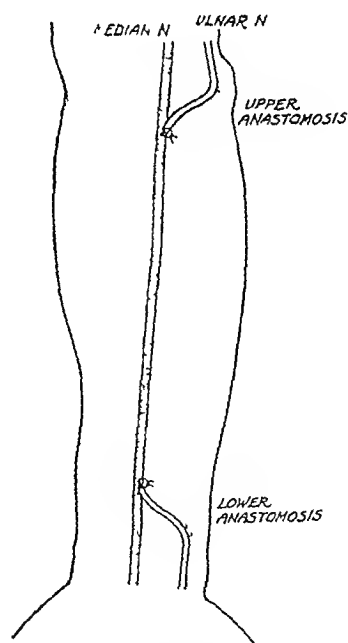


FIG 224—Double implantation of ulnar nerve into median

Monkey C "runs about normally Scratches itself with operated limb There is active raising of the foot (true extension) The toes do extend, but at rest they are kept slightly flexed'

Monkeys B and C lived for twenty months and Mr Dolbey told me that for many months before they died he was unable to observe any clinical evidence of weakness in the operated limbs I hope some day to report with Mr Dolbey more fully concerning these experiments

During the great War I adopted the method of double lateral implantation in those patients in whom no other method was practicable The operations performed (*Figs 221 to 224*) were as follows —

1 The external popliteal was implanted in two places into the internal popliteal

2 The musculospiral was implanted in two places into the median

3 The median in the forearm was implanted in two places into the ulnar

4 The ulnar in the forearm was implanted in two places into the median

I lost sight of most of these cases, as I was away from England for years, and each man was sent to England, usually not long after the operation had been performed I have been told that in some cases the anastomosis was unwound by the surgeon in England under whose care they came for one of the following reasons (1) The operation was a failure, (2) The nature of the operation was not appreciated or (3) The surgeon's mind was obsessed by the neurone theory and he was unable to reconcile the cherished theory with the operation which had been performed

For my part I hold that the views of *Durante* as expressed in *Cornil and Ranvier* are a masterly exposition of the true pathology of the peripheral nerves He writes "The axis cylinder can no longer be regarded as a gigantic process from a cell making its way through ensheathing cells an organ without any analogy in the economy an element without any life of its own existing only by virtue of its far distant central cell The nerve tube appears to us as a chain of cells in functional relation but with individual life Each interannular segment represents a single complete element the segmental neuroblast the protoplasm of which has secreted *in situ* the differentiated substances—the fatty substance myelin and the axis-cylinder fibril The axis cylinder is no longer an organ of central origin but simply a fibrillar bundle differentiated within each segmental cell Viewed thus, the nerve tube no longer forms a monstrosity, unique in the economy, but conforms to the general plan of the organism as a cellular colony, the elements of which react according to the same fundamental principles as do the cells of other tissues Those who hold to the belief that a peripheral nerve is laid down as a chain of cells and that within the protoplasm of each cell the myelin sheath and axis cylinder are developed have no difficulty in understanding the wonderful success of the operation of double lateral implantation

Case I —Posterior cord of the brachial plexus implanted in two places into the side of the outer cord

Four weeks ago I saw for the first time since 1917, that is, six years ago a soldier who was wounded in the left shoulder in an attack on the Turks on the

Dorian front at Salonika. The subclavian artery and brachial plexus had been wounded. When the patient was first seen the left arm was paralysed and a subclavian aneurysm occupied the lower part of the neck. Operation was necessary: the clavicle was divided and the artery above the aneurysm (subclavian) and that below (axillary) were ligated. The aneurysm was removed. It was then seen that the posterior or middle cord of the brachial plexus had been destroyed

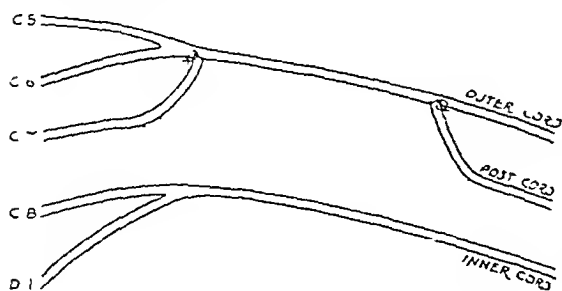


FIG. 225 - Double implantation of posterior cord of brachial plexus into outer cord

by the projectile for a considerable distance. The distal end of the proximal fragment of the posterior cord was implanted into the side of the outer cord of the plexus—that formed by the junction of the anterior primary divisions of the 5th and 6th cervical nerves and the proximal end of the distal fragment was implanted, lower down into the side of the outer cord or perhaps into the commencement of the median nerve (Fig. 225). In this case there was no other possible operation but

double lateral implantation of the ends of the damaged nerve. The condition of the limb a month ago was as follows. Arm, forearm and hand much wasted, all muscles react to the faradic current and all muscles react voluntarily with the exception of the extensor longus pollicis and the extensor longus digitorum. The patient had only had intermittent treatment, and Dr. Bailey, under whose care he has recently come, hopes that with proper and continuous treatment great improvement of the condition of the limb will take place.

Case 2—Median nerve in forearm implanted in two places 5½ inches apart, into the side of the ulnar nerve.

I operated on this soldier in September, 1917 at Malta. For all purposes he has a useful hand, but he does not employ it for writing because he has become accustomed to use the left hand for this purpose. The condition of the hand is in no small measure due to the fact that on returning to England he came under the care of Mr. Joyce at the Reading War Hospital. Thirty-four months after operation he was examined by the Committee on Nerve Injuries appointed by the Medical Research Council. They point out in their report that sensibility to pin-pricks was present over the terminal phalanges of the index and middle fingers, but that sensibility to cotton-wool was wholly absent. This last insensibility still remains at the ends of the index and middle fingers. The photographs show very clearly the success of the operation (Figs. 226-228). This man is at work.

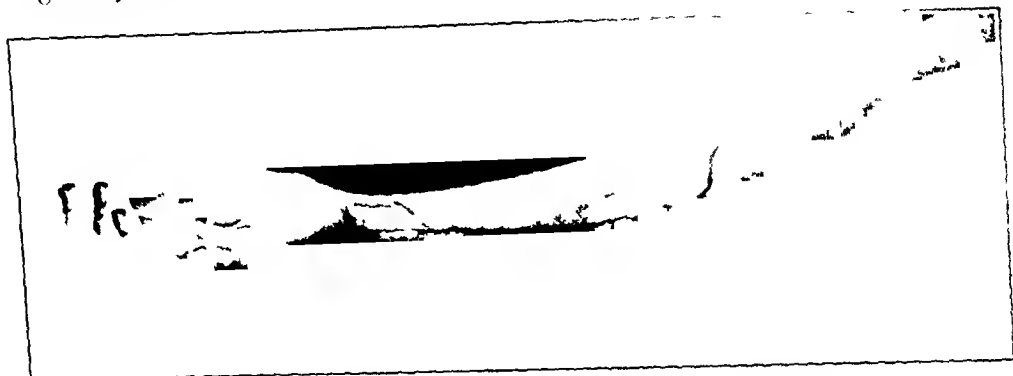
Case 3—Ulnar nerve in forearm implanted in two places 3½ inches apart into the side of the median nerve (Mr. Joyce).

This case was examined, two years after the operation, by the same Committee as examined Case 2. The man had a useful hand. No defect could be demonstrated in the functions of the median nerve, though it had been cut across one-third of its diameter in two places in order to effect the anastomosis. The muscles supplied by the ulnar responded to faradic stimulation, but it was doubtful if the abductor minimi digiti was voluntarily contracted. Pin-pricks were appreciated within the whole ulnar region except over the terminal phalanx and ulnar border of the middle phalanx of the little finger.

Since this patient was reported on by the Committee of the Medical Research Council he has recovered voluntary power in the abductor minimi digiti and the abductor brevis pollicis. Faradic response can be obtained in all the ulnar intrinsic muscles. The man is at work.

SOME RESULTS OF NERVE ANASTOMOSIS 333

Both *Cases 2 and 3* and *Case 7* much interested the members of the Congress present at the demonstration



FIGS. 226, 227, 228.—Photographs of the present condition of the forearm and hand in *Case 2*. The black lines in the forearms show approximately the operation performed: double lateral implantation of the median nerve into the ulnar nerve.

Case 4—End-to-end anastomosis of the ulnar nerve of a man age 26 years, two inches above the wrist.

The operation was performed fourteen months ago and the case serves for the purpose of comparison with the operation of double lateral implantation. The nerve was divided in a wound made by a narrow chisel five weeks before the end-to-end anastomosis was done. Since the anastomosis the man has attended daily at St. Thomas's Hospital for massage and electrical treatment under Drs. Mennell and Leitch, so that he has had the very best opportunity of early recovery. The wounds made by the chisel and at the operation both healed by first intention.

Four months after operation—The ulnar muscles gave no response to faradism.

Six months after operation—There was a faradic response in the 2nd palmar interosseus and in the abductor minimi digiti.

Seven months after operation — Faradic response had returned in all the interossei except those of the 4th space Sensation was perfect except at the tip of the little finger
 Ten months after operation — Faradic response in all muscles of the hand supplied by the ulnar nerve Voluntary response improving Sensation normal
 Fifteen months after operation — The muscles of the hand supplied by the ulnar nerve are still wasted and though the hand is improving as compared with what it was like six months ago, yet it still retains the characteristic appearance of ulnar nerve palsy

EXPERIMENTS

Double lateral implantation (Dr Bailey's examinations)
 1 Rhesus Monkey — External popliteal attached in two places, $\frac{1}{2}$ in apart to internal popliteal

Five months after operation — Faradic response in peronei muscles and in tibialis anticus Flexors of ankle normal
 Seven months after operation — Extensor communis digitorum and extensor hallucis respond to faradism The toes extend in walking before the foot is placed on the ground but it rest the toes are somewhat flexed It should be remembered that splint treatment, so as to keep the extensors relaxed during the period of recovery is not possible in the monkey This monkey is no longer lame and climbs about in the normal manner

2 Rhesus Monkey — Median nerve of forearm attached in two places, $\frac{1}{2}$ in apart to the ulnar
 Five months after operation — Faradic response is present in all muscles of hand supplied by median nerve
 Six months after operation — The hand is being used in the normal way, except that when food is offered, the undamaged hand takes it

3 Rhesus Monkey — Ulnar nerve of forearm attached in two places, $\frac{1}{2}$ in apart, to median nerve
 Four months after operation — Faradic response is present in all muscles of the hand supplied by the ulnar
 Five months after operation — The hand is being used in the normal way but when food is offered, the undamaged hand takes it

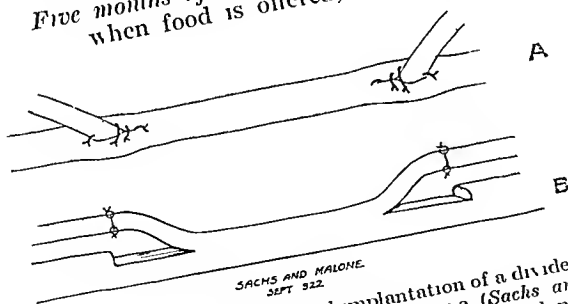


FIG. 229 — Double lateral implantation of a divided nerve into a neighbouring healthy nerve (Sacks and Malone) A The method of choice B Method not recommended as it does unnecessary damage to the healthy nerve

An important experimental paper was published by Sacks and Malone in the *American Journal of Surgery*, Chicago, in September, 1922, on double lateral implantation for bridging nerve defects

In 1918 one of them after removing a tumour of the ulnar nerve, found that there was such a large gap that it was impossible to get both ends together He therefore im-

planted the central and peripheral ends into longitudinal slits in the median nerve The result was a great success The distance apart of the implanted ends varied from 1 to 6 cm The implanted ends of the nerve were sutured to longitudinal incisions in the normal nerve Complete recovery occurred in all the experiments They were eighteen in number In all the

external popliteal nerve was grafted in two places into the internal popliteal nerve. Numerous other experiments are described. In one series flaps were cut from the intact nerve so that they could be joined end to end with the two ends of the implanted nerve (*Fig 229 B*). This method is not recommended as it does unnecessary injury to the normal nerve. In another series an autotransplant at half the divided central end was fashioned to fill the gap in the nerve. This method like the last method is not recommended. Double lateral implantation gives the best results (*Fig 229 A*) it is the simplest operation and the method of choice. The authors made numerous microscopic examinations. It appeared from these researches and from other tests that the fibres of the upper implanted portion of the external popliteal nerve became joined not only with fibres of the distal implanted external nerve but also with fibres of the internal popliteal nerve.

Since the date of the demonstration Mr. Joyce has kindly sent me notes of five other cases in which he has performed the operation of double lateral implantation of the divided ends of the ulnar nerve into the median.

Case 5—Shell wound of left forearm March 25 1915. Complete division of ulnar nerve. (*See BRITISH JOURNAL OF SURGERY 1919 VI 127*)

Feb., 1916—Admitted with advanced irreducible clawing of all fingers.

Operation—Double lateral implantation of the two ends of ulnar nerve into median, 16 cm. apart. The patient went to Ireland.

Extract from letter from patient Nov. 28 1917—“I have nearly all the feeling restored to my hand the most sensitive being the little finger. It would be quite surprising to you to see how the hand has improved since your operation.”

Extract from letter from Sir Thomas Miles Feb. 9 1918—“The man can close all his fingers and give a good grip. Power and sensation are improving.”

Case 6—Bullet wound of right forearm with injury to ulnar nerve Nov. 12 1917.

Operation Dec. 19 1918—Gap of $3\frac{1}{2}$ in. dealt with by double lateral implantation of ulnar into median nerve.

Present condition, July, 1923—Complete recovery of sensibility to pinprick in ulnar area. Faradic response in all ulnar intrinsics. Voluntary power in flexor brevis minimi digiti and abductor minimi digiti. Ulnar intrinsics still considerably wasted and hand clawed. Man working.

(This case was also shown by Mr. Joyce at the demonstration.)

Case 7—Gunshot wound of left forearm. Compound fracture of left radius and ulna and injury to ulnar nerve Aug. 27 1918.

Operation, Nov. 8 1919—Gap of $3\frac{1}{2}$ in. in left ulnar nerve dealt with by double lateral implantation of ulnar into median nerve. Case transferred Edmonton, April 19, 1920, and not seen or heard of since.

Case 8—Shrapnel wound of left forearm Sept. 18 1918 with compound fracture of left ulna and division of left ulnar and median nerves.

Operation June 14, 1919—Gap of 1 in. in median nerve end-to-end suture. Gap of 4 in. in ulnar nerve bridged by double lateral implantation of ulnar into median nerve.

Last examination, March 19, 1920—“Sensation returning in both median and ulnar areas. No faradic response in the intrinsic muscles of left hand. Good galvanic response to a small current.”

Case 9—Gunshot wound in right forearm Sept 5, 1916, with division of ulnar nerve

Operation March 21 1917—Gap of $1\frac{1}{2}$ in in ulnar nerve bridged by double lateral implantation of ulnar into median Patient discharged from the army in August, 1917 and lost sight of

II THE EVOLUTION OF THE OPERATION FOR THE CURE OF FACIAL PALSY

The first operation performed for the relief of facial palsy was in 1895 The operation selected was the suturing of the divided end of the facialis into the side of the spinalis part of the spinal accessory nerve (*Fig 230 A*) In the following years the facialis was attached in various ways to the spinalis (1) By making a flap of half the thickness of the spinalis and uniting it end-to-end with the facialis, (2) By completely dividing the spinalis and uniting it end-to-end with the facialis (*Fig 230 B*) (3) By dividing the branch of the spinalis going either to the trapezius or sternomastoid muscles and uniting the proximal end of the divided branch end-to-end to the facialis

Meanwhile Barrago-Ciarella and Manasse carried out certain experiments

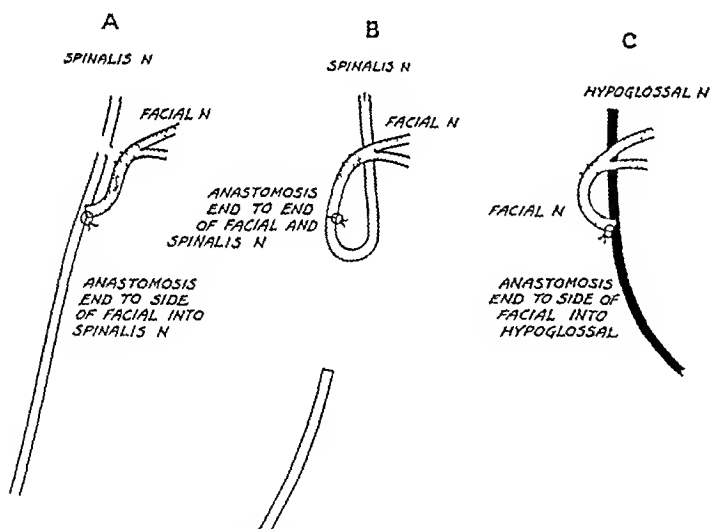


FIG. 230—Anastomosis of the facialis with other nerves. A Facio spinalis anastomosis end to side B Facio spinalis anastomosis end to end C Facio hypoglossus anastomosis end to side

on facio-spinalis and facio-vagus anastomosis on dogs, in which it was shown that recovery in the case of facio-spinalis anastomosis was complete in six months and in the case of facio-vagus anastomosis in eight months

The results obtained in man however were not satisfactory in spite of some brilliant exceptions The interference with the spinalis was followed invariably with more or less deformity of the neck and shoulder due

to weakness or partial atrophy of the sternomastoid or trapezius or both This is shown very clearly in a case by Kummer*, who performed the operation ascribed to Giant of Denver End-to-end anastomosis between the spinalis and facialis was done and then, in order to obviate the atrophy following the division of the spinalis, the distal cut end of this nerve was united end-to-end with the proximal cut end of the descendens noni (*Fig 231*) The

nerve-supply of the depressor muscles of the hyoid bone and larynx was sacrificed to enervize the two great muscles supplied by the spinalis. The final result in the patient a woman was marred by atrophy of the trapezius. This is well shown in the figure illustrating Kummer's paper.

Further associated movements of the side of the face and shoulder is always the first and sometimes the permanent result of facio-spinalis anastomosis. Dissociated movement of the face and shoulder is rare requires a long patient period of re-education and may never be regained even after years of effort. Again symmetrical subconscious emotional movement of the two sides of the face in which the cortical centres of opposite sides of the brain must co-operate in harmony—the movement which is most desired—is the one which most frequently eludes recovery.

The following case is of much interest in relation to this question. Three years after the occurrence of facial palsy due to fracture of the base of the skull, the cut end of the facialis was united to the side of the spinalis. Associated movements between the face and shoulder were first noticed five months later and by the end of the year the whole face became much disordered by any sudden movement of the shoulders. Ten years after the operation the patient was in Geneva, there was then no dissociated movement of

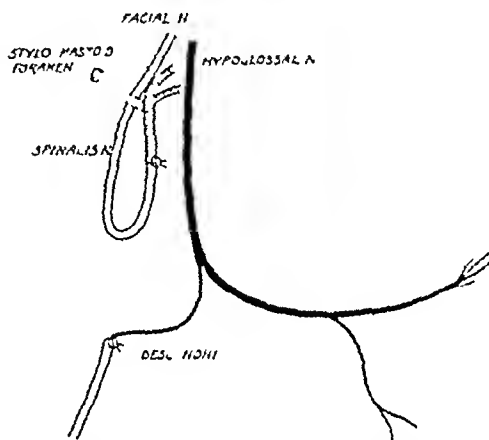


FIG. 231.—Diagram of an operation (Grant Kummer). (1) Facio spinalis anastomosis end to end. (2) Descendens noni spinalis anastomosis end to end.

face and shoulder. She consulted Professor Guaid. Under local anaesthesia the trunk of the spinalis distal to the anastomosis was divided and immediately sutured. The patient was then asked voluntarily to move the angle of the mouth. She found she could do so, though this had never been possible before. Dissociated voluntary movement of the face from this time gradually improved and three months later she could contract all the muscles of the affected side of the face powerfully by voluntary effort. The end-to-side anastomosis in this case was an attempt to cure the face and at the same time not to interfere with the muscles supplied by the spinalis. The attempt failed—the whole nervous energy flowing through the spinalis was required for recovery of the voluntary movement of the face. It is absolutely necessary to concentrate the attention on the main issue of the case, and let all subsidiary issues take care of themselves in such a difficult problem as the cure of facial palsy. It has been well said "On this earth of ours what great good has ever been, or can be gained except by sacrifice? It is in every era and in every zone, the law of life."

It is natural then, that a search should be made for some other nerve which might give better results when anastomosed with the facialis than the spinalis. A distinguished physiologist suggested the glossopharyngeal nerve but its smallness and relative inaccessibility did not commend the employment

of this nerve to the tongue.⁴ The vagus too in man notwithstanding successful experimental results is so important a nerve that its use for anastomosis with the facialis has not been attempted.

In 1901 the facialis was sutured to the side of the hypoglossus (*Fig 230 C*), but one year later the result was only a partial success. It was gradually recognized that in order to win success it was futile to try to save the hypoglossus as well as to cure the facial palsy. In war and in surgery two main objectives are likely to end in failure. Thus it came to pass that the whole hypoglossus was divided and united end-to-end with the facialis. This operation led to atrophy of one half of the tongue and though this deformity of the tongue was of little moment yet in 1906 a slip cut from the spinalis was brought across the neck and anastomosed to the distal cut end of the hypoglossus (*Fig 232*). A few years later the divided descendens noni was

united to the distal cut end of the hypoglossus (*Fig 233*). In another case the divided gustatory nerve was united end-to-end with the distal cut end of the hypoglossus. Years afterwards all these patients were seen and in each the tongue was protruded straight and the side of the tongue which had been atrophied and paralyzed was of normal size and movement. The combined facio-hypoglossal and descendens-noni-hypoglossal operations give good results and can be recommended.

A case of facial palsy in a woman age 50 was treated by operation on Dec 2 1922. Complete facial palsy had been caused eight and a half months previously by acute suppuration. The notes illustrate the case.

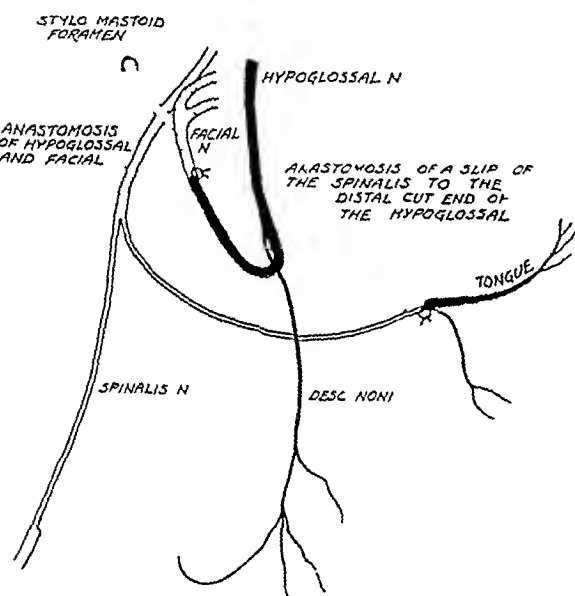


FIG 232 — Operation (1) Facio hypoglossus anastomosis end to end (2) Spinalis (part of) and hypoglossus anastomosis end to end

signs of recovery. The anastomoses carried out were (a) Facio-hypoglossus anastomosis, end-to-end, and (b) Descendens-noni-hypoglossus anastomosis, end-to-end. The trunk of the facialis where exposed looked red and unhealthy, and on stimulating the cut end no contraction occurred in any of the muscles of the face.

Six months after operation — The asymmetry of the two sides of the face was less marked, and the palpebral fissure on the paralyzed side was less wide. The tongue was protruded straight, and showed little sign of atrophy.

Seven months after operation—The pulchral fissure was scarcely wider than on the healthy side

Eight months after operation—Slight voluntary contraction of the levator labii superioris was observed

Eight months and three weeks after operation—Definite voluntary movement of the levator labii superioris and the levator anguli oris was present, but only the lower half of the orbicularis palpebrarum reacted to the faradic current

The following case illustrates the advantages when nerve anastomosis has to be done of youth and of early operation. Cases of facial palsy are left far too long under what is called medical treatment. A woman age 21 was operated on for right mastoid suppuration in a country town. Complete facial palsy followed. It was found afterwards that the vertical part of the canal of Fallopius and its contents had been cut away.

Two months after the mastoid operation the nerves were anastomosed as in the preceding case i.e. facio-hypoglossus anastomosis end-to-end and descendens-noni-hypoglossus anastomosis end-to-end, were carried out. The trunk of the facialis looked white and healthy and on stimulating the cut end contraction of all the muscles of the face occurred.

Two months after operation—The symmetry of the face at rest had much improved. The right eye, too, was not so widely open as before.

Three months after operation—Slight voluntary movement of the angle of the mouth was present, as was also slight associated movement of the angle of the mouth when the tongue was moved backwards and forwards quickly.

Four months after operation—Voluntary movement of the angle of the mouth much more definite. Tongue atrophy almost disappeared. No faradic response yet in the muscles except a slight one in the orbicularis palpebrarum.

Seven months after operation—The two sides of the mouth move nearly equally in smiling. There is distinct voluntary movement in the frontalis. All muscles react to faradism, but the reaction is not so strong or quick as the normal. The tongue is protruded straight and the right half is nearly equal in bulk to the other or normal half. Patient says she can taste on the right side of the tongue but not so well as on the other side. She is quite sure of this, and says she had noticed for some weeks that the sensation of taste was returning on the right side of the tongue, but on testing no evidence of return of taste was found. The patient's statement may be correct just as voluntary movement may return in a muscle before the surgeon can detect any response to faradic stimulation.

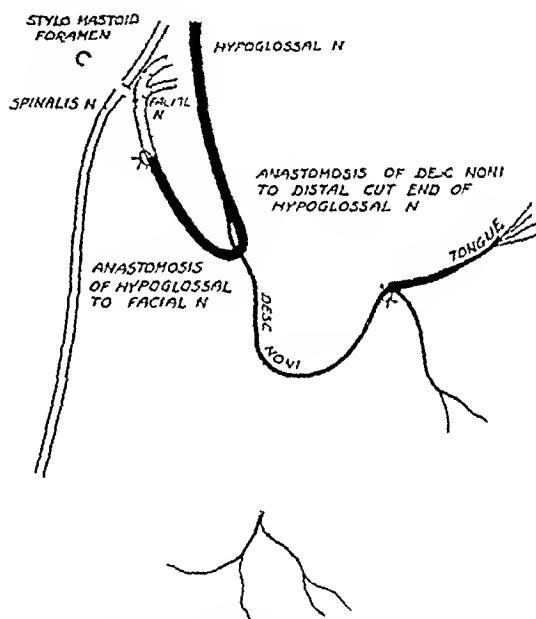


FIG 233.—Operation (1) Facio hypoglossus anastomosis end to end (2) Descendens noni hypoglossus anastomosis end to end

The suggestion to obtain recovery from lingual atrophy by passing the divided distal end of the hypoglossus through the hyoglossi and geniohyoglossi muscles and anastomosing it with the hypoglossus of the opposite side does not seem advisable. The more complete paralysis of the tongue produced by simultaneous interference with both hypoglossi would give rise to serious discomfort and inconvenience.

When the hypoglossus was first used for anastomosis with the facialis, it appeared theoretically to be superior to anastomosis of the facialis with the spinalis, for the representation of the movements of the shoulder on the cortex are far away from the representation of the movements of the face while the representation of the movements of the tongue are in close proximity to the representation of the movements of the face and mouth,

and, moreover, some facial fibres in the medulla are connected with the hypoglossal nucleus. Again the hypoglossus in a healthy person is accustomed to work with the facialis for the purposes of mimetic expression. If associated movements are present they are slight, do not trouble the patient and are not seen, whilst the associated movements of the shoulder and face which occur after facio-spinalis anastomosis are ugly and troublesome.

The return of the sensation of taste on the side of the tongue after any of these anastomoses is truly a remarkable fact. Seven months after a facio-hypoglossal and a descendens-nom-hypoglossal anastomosis were performed, the patient declared that every week she noted an improvement in the

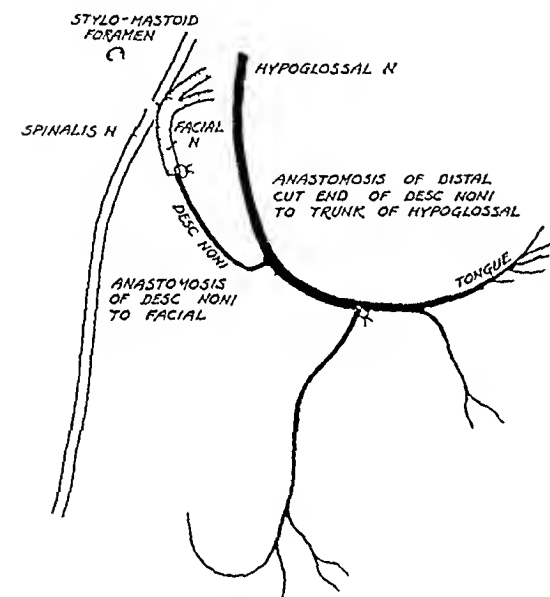


FIG. 234.—Operation (1) Facio descendens nom anastomosis end to end (2) Descendens nom hypoglossus anastomosis end to side

power of tasting food on the side on which this sensation had been absent. Eight years after the divided lingual had been united end-to-end with the distal end of the hypoglossus, and twelve years after a facio-spinalis anastomosis had been performed, the sensation of taste, on suitable tests being made, was found to have completely returned on the side of the tongue.

A view of the descendens nom during an operation on the side of the neck of an adult, which seemed to be, but probably was not, unusually large suggested a further stage in the evolution of the facial palsy operation. Was it possible to employ with success the descendens nom, and leave intact both the spinalis and the hypoglossus? The only way to elucidate this point was by experiment. In the monkey the descendens nom was divided and sutured end-to-end to the divided facialis and the distal cut end of the descendens nom was united end-to-side to the lower border of the hypoglossus (Fig. 234).

SOME RESULTS OF NERVE ANASTOMOSIS 341

The latter anastomosis was done in order to avert permanent paralysis and atrophy of the depressor muscles of the hyoid bone and larynx. These operations were successful. In two and a half to three months (in various monkeys) from the date of the operations faradic excitability had returned in all the muscles of the face and in five and a half months no appearance of paralysis could be observed except that the animal preferred to place food (e.g. a green-gage) in the pouch on the side of the mouth which had never been paralysed, but this had possibly become a habit. Three months after the operations

in these monkeys, while they were being fed with apple, plum or fig, a remarkable movement of the upper eyelid and pinna on the previously paralysed side was observed. It had before been noted that the palpebral fissure was no longer more widely open than on the normal side. After the larynx and hyoid have been drawn up with the pharynx in the act of deglutition, the depressor muscles come into action and return the hyoid and larynx to their normal position. On swallowing in these monkeys, when the depressor muscles contract, and perhaps also in consequence of movements of fixation of the tongue, the upper eyelid was in intermittent movement, frequently closing over the eyeball, and further rapid to-and-fro movements of the pinna occurred, as if the retractor auricularis muscle was in intermittent contraction*. In other words, there was clear evidence of an associated movement between the muscles supplied by the descendens noni and some of the muscles supplied by the facialis. The

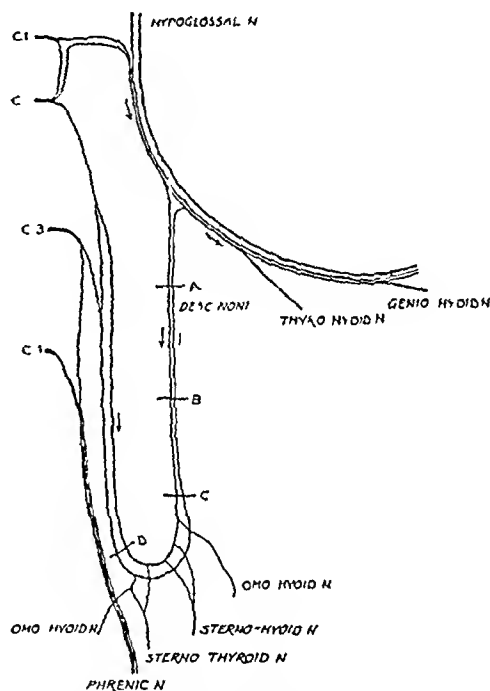


FIG 235.—The spinal origins of the descendens noni and communicans noni (after Testut). A B C D Points on these nerves which were stimulated by Professor Kummer.

two anastomoses were functioning and so far the experiments were successful.

The descendens noni had been cut in the upper third of its course before any of its branches had been given off, and so by the anastomosis the whole of the nervous impulses which flow along it were transferred to the facialis. Professor Kummer† stimulated the descendens noni in dogs, and confirmed the results obtained by stimulating the descendens noni in man (Fig 235). His conclusions are —

- 1 The descendens noni and communicans noni convey motor impulses

* Monkeys were fed, and these movements were demonstrated to members of the Congress. The early recovery of the muscles around the eye in the monkey after descendens noni-facialis anastomosis is quite different from what is observed in man after facio-spinulus or facio-hypoglossus anastomosis.

† *Revue Medicale de la Suisse Romande*, 1915, July.

The results obtained by stimulating different parts of the descendens noni vary, as motor impulses descend and ascend in this nerve

2 In the upper third (*Fig* 235, A) the usual effect of stimulation is depression of the larynx, but occasionally elevation of the larynx and contraction of half the tongue occur

3 In the middle third (B) stimulation shows that the motor impulses both descend and ascend. Sometimes depression of the larynx is strong (*contraction forte*)

4 In the lower third (C) stimulation produces depression of the larynx

5 Stimulation of the communicans at D causes contraction (*contraction faible*) of the depressor muscles

It follows therefore that the right place to cut the descendens noni for anastomosis with the facialis is in the upper part of its course

It seems very difficult of explanation that when an electric stimulus is applied at A or B on the descendens noni sometimes depression and sometimes elevation of the larynx occurs. The muscles concerned in these antagonistic movements must however be very intimately connected for according to the Sherrington view of muscle action, when the depressors act the elevator will relax and vice versa. According to Kiebel and Mall (*Human Embryology*, 1910 vol 1) the infrahyoid muscles arise from a common mass of muscle which migrates down the neck and drags its nerve-supply with it. It is therefore possible that a motor filament to the thyrohyoid muscle might be dragged down the descendens noni and then return again to travel along the hypoglossus till it reaches the spot where the other filaments to the thyrohyoid leave the hypoglossus to reach the muscle they supply.

The other more likely explanation appears to me to be this. The stimulus received by the descendens noni at A or B when elevation of the larynx takes place may actuate a sensory impulse whose motor reflex causes contraction of the thyrohyoid.

Can this problem be solved? Sir Charles Sherrington suggested to me that the descendens noni should be cut at B and the proximal end stimulated. Presumably contraction of the thyrohyoid would take place. Then cut the hypoglossus proximal to the origin of the descendens noni and stimulate again. If contraction of the thyrohyoid occurs, it is due to a returning motor filament. If no contraction is observed the stimulus was previously activating a sensory filament whose centre for reflex action has been now cut off.

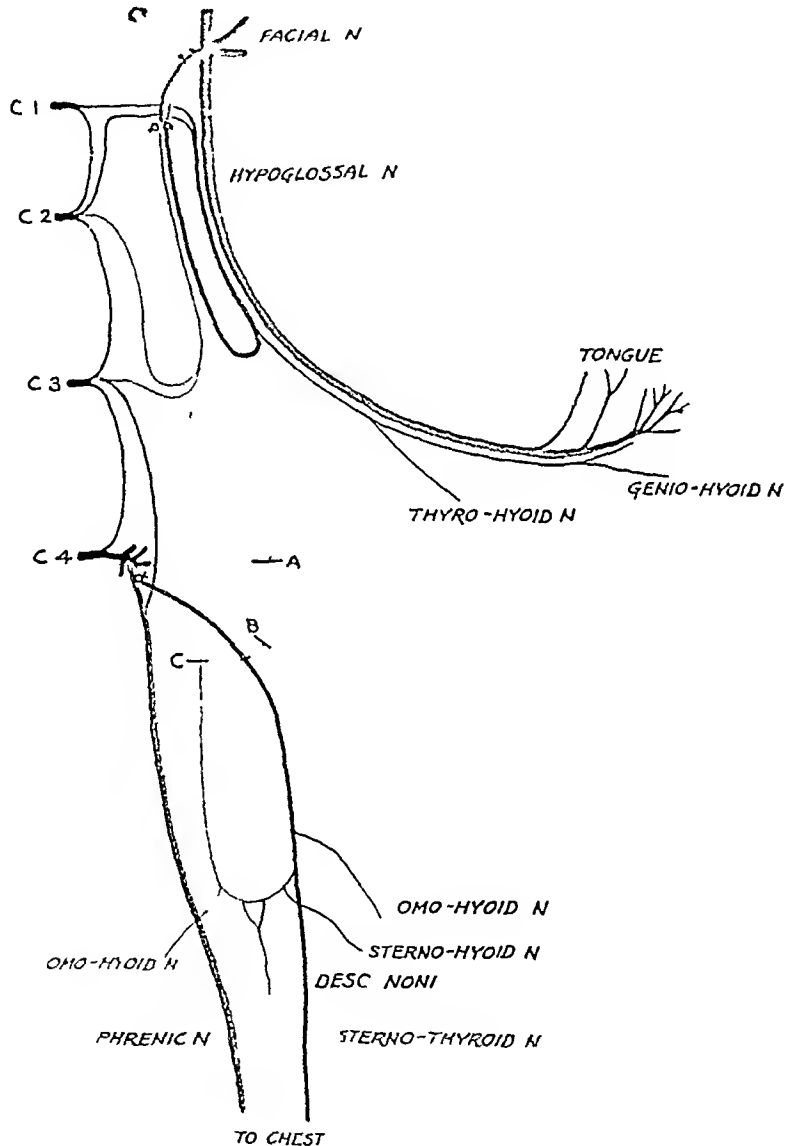
As a further step it is proposed to reinforce the descendens noni nerve energy available for the recovery of the facialis by attaching also the proximal end of the divided communicans noni end-to-end to the facialis,* the communicans noni being divided before any muscular branches are given off, in order as in the case of the descendens noni, to conserve all its nerve impulses for functioning the facialis. The distal cut end of the communicans could be sutured to one of the numerous nerves arising from the anterior primary division of the 3rd or 4th cervical nerve.

* Since the date of the demonstration this operation has been done in the monkey (*See Fig* 236)

It is curious that in the evolution of the operation for facial palsy the nerve first used for the anastomosis and the nerves now suggested for the anastomosis, should all have an origin from the cervical spinal cord. The spinalis arises from the motor cells of the outer part of the anterior horn of

FIG 236.—Operation
A, Site of section of descendens noni nerve B and C Sites of section of communicans noni nerve. The figure shows (1) Descendens noni facialis anastomosis end to end (2) Descendens noni phrenicus anastomosis end to side (3) Communicans noni facialis anastomosis end to end (4) The distal cut end of the communicans noni was so minute that no attempt was made to suture it to another nerve.

The operation was done on a fairly large monkey. The descendens noni was relatively a large nerve which descended into the chest, while the communicans noni nerve was very small and could only be followed with the aid of a magnifying glass. It will be noticed that the two nerves communicated rather high up and that there was another 'ansa' lower down, from which the nerves to the depressor muscles of the larynx were given off.



grey matter of the spinal cord from the level of the 1st cervical nerve to as low as the 5th cervical nerve. The latest operation is a double anastomosis of the facialis—to the descendens noni, which arises from the 1st and 2nd cervical nerves, and to the communicans noni, which arises from the 2nd and 3rd cervical nerves.

EXPERIMENTS

Facio descendens noni anastomosis in the monkey (Dr Bailey's examinations)

1 BABOON —

Five months after operation all muscles of face respond to faradic current, with the exception of the occipitofrontalis. All deformity of the face has passed away.

2 SMALL RUESUS MONKEY —

Three and a half months after operation all muscles of the face respond to faradism except the orbicularis oris and the occipitofrontalis.

Four months after operation all the muscles of the face react to faradism.

3 RUESUS MONKEY —

Four months after operation the orbicularis palpebrarum and the levator labii superioris react to faradism the others do not.

Six months after operation the two sides of the face are quite symmetrical.

III THE ANASTOMOSIS OF THE DIVIDED RECURRENT LARYNGEAL NERVE WITH THE DESCENDENS NONI NERVE OR WITH THE VAGUS

Some years before the war I united the cut recurrent laryngeal nerve to the vagus, but the patient disappeared so the result of the anastomosis is not known*.

Dr Frazier, of Philadelphia, told me a day or two ago that at the suggestion of Dr Cheever Jackson he had recently united the recurrent laryngeal nerve to the descendens noni.

The question of the value of the anastomosis of the divided recurrent laryngeal with another nerve could only be decided by experiment. In two goats and one monkey recurrent-laryngeal-vagus anastomosis was performed, and in three monkeys recurrent-laryngeal-descendens-noni anastomosis was done. On cutting the recurrent laryngeal in each experiment the distal cut end was stimulated. The vocal cord which had been paralysed by the division of the nerve, was seen to abduct in a normal manner.

On examining the larynx with the bronchoscope in each of these animals at varying periods up to 200 days after the operation no respiratory movement of the vocal cord was observed. But a change in the appearance of the vocal cord did take place. At first a typical cadaveric position was

* A COTTERILL — *The Veterinarian*, 1893, June. Recurrent laryngeal vagus anastomosis was done in dogs and in a donkey. The idea was to determine whether roaring in horses could be cured by recurrent-laryngeal-vagus anastomosis. In dogs it is said that in six months the vocal cord which had been paralysed by the operation was working again and in the donkey recovery of the cord took only three months.

B MACDONALD — *International Congress at Rome*, 1894. Reports that he united the recurrent laryngeal to the vagus in a horse. Roaring was produced and is said to have gradually passed off.

C NAVARIN — *Arch. internat. de Laryngol., d'Otol. et de Rhinol.*, 1910. Described suture of the recurrent laryngeal nerve to the descendens noni in four dogs. The final functional result is not clear.

D SHULTON HORSLEY — *Ann. of Surg.*, 1910. Described the suture of the divided ends of the recurrent laryngeal nerve. The injury was caused by a bullet wound. The patient was a woman. Thirteen months after the operation almost perfect motility of the previously paralysed vocal cord was observed.

assumed and the inner border was concave, but after from six to eight weeks from the date of operation the inner border of the immobile vocal cord became straight and tense*. There was in fact a tone about the paralysed cord which had not been present before. The change of tone about the vocal cord occurred in all the experiments—whether recurrent-laryngeal-vagus or recurrent-laryngeal-descendens noni anastomosis had been done.

Fifty days after a descendens-non-recurrent-laryngeal anastomosis (Fig 237) had been performed in a monkey, the wound was opened, and the anastomosis was exposed. On stimulating (1) the hypoglossus proximal to the origin of the descendens noni (2) the descendens noni, and (3) the site of anastomosis the vocal cord was seen through the bronchoscope to abduct. This showed clearly that the anastomosis was, at any rate in part, functioning.

Seven months after a recurrent-laryngeal-vagus anastomosis had been done in a monkey (Fig 238), the wound was re-opened. The vagus was stimulated (1) proximal to the anastomosis, and (2) at the site of anastomosis. These stimulations caused abduction of the vocal cord; the excursions of the cord were not so wide as on the opposite or healthy side. Subsequently (when the abductor was tired) strong adduction was observed. These observations were made not only by Mr Colledge, but also by Dr Gabriel Tnekei, chief assistant to Dr Chevalier Jackson. Previous to the stimulation it was also agreed that the immobile cord

was straighter and exhibited more tone than a cadaveric cord. The conclusion is obvious: the anastomosis was, so far, a success.

After the operation for the cure of facial palsy, when the patient has recovered voluntary power over the muscles of the face, the associated emotional movements of the two sides of the face require a long period of re-education by voluntary effort before they are perfect. Voluntary abduction or other movement of the vocal cord is not possible. The movements of the vocal cord are subconscious acts. The harmonious subconscious

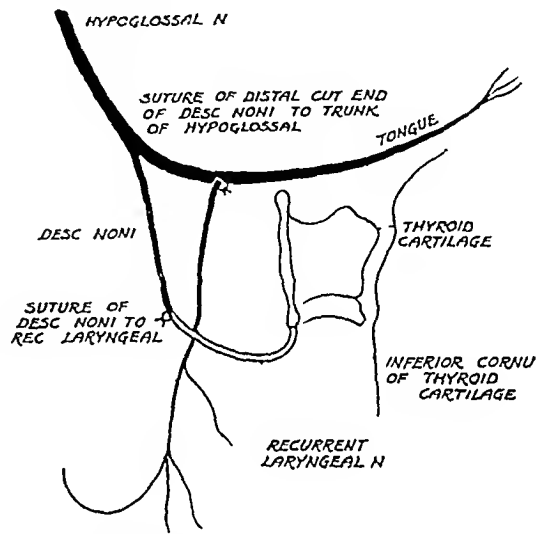


FIG 237.—Operation (1) Descendens noni recurrent laryngeal anastomosis end to end (2) Descendens noni hypoglossus anastomosis end to side

From previous experiments it may be inferred that when these two anastomoses function, there will be at first during swallowing an associated movement of the muscles of the vocal cord with the elevator and depressor muscles of the larynx. The intermittent nervous energy flowing along the nerves distributed to these muscles during swallowing might possibly be a factor in the recovery of normal respiratory movement in the immobile vocal cord.

* The vocal cord in this condition was shown to members of the Congress

movements of the two vocal cords if such happens after anastomosis of the recurrent laryngeal to the *vagus* or the descendens noni need not take longer I think, to recover than the associated voluntary movements of the face after operation for facial palsy. The difference lies in the possibility of treatment. In the case of the face muscles, re-education of the associated movements of the two sides of the face is practicable by voluntary effort but any such re-education is impossible in the case of the muscles controlling the movements of the vocal cords.

In discussing this question with Professor Stirling he suggested that if the animal was partially asphyxiated the inspiratory effort would become so powerful that the muscles of the immobile vocal cord might receive sufficient nervous energy to contract. Professor Stirling's suggestion was at once acted on.

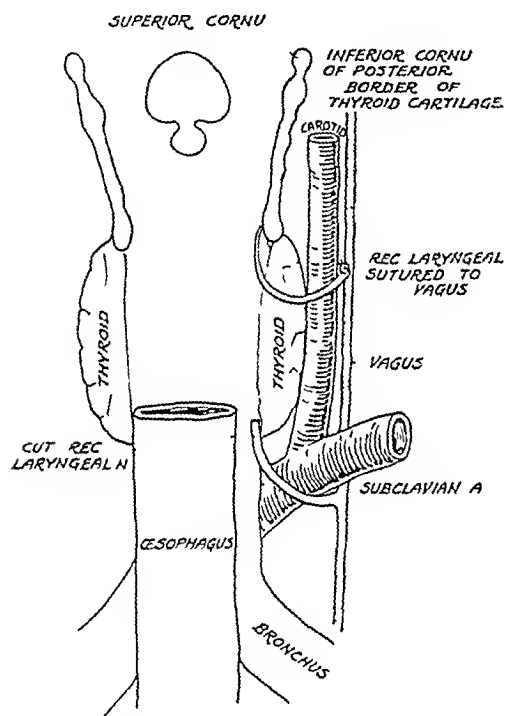


FIG 238.—Operation. Recurrent laryngeal *vagus* anastomosis—end to side (Viewed from behind)

again. The experiment however, possibly gives the key to the problem of the re-education in man of the vocal cord after anastomosing the recurrent laryngeal with another nerve.

In man, partial asphyxia can be readily and voluntarily induced by 'holding the breath.' 'Holding of the breath' is necessarily followed by a strong inspiratory effort, which would probably cause in man as in the monkey experiment, abduction of the previously immobile vocal cord. By repeating the experiment daily for a considerable period of time, it seems not unlikely that a patient's immobile vocal cord might at last be re-educated to act in a harmonious, subconscious, normal respiratory movement with the vocal cord of the opposite or healthy side.

A monkey on which a descendens-non-recurrent laryngeal anastomosis had been performed four and a half months previously was placed under ether anaesthesia. The bronchoscope was inserted and gentle pressure made on the trachea. This induced strong adduction of *both* vocal cords. As soon as the pressure on the trachea which had produced partial asphyxia was relaxed wide outward excursions of *both* vocal cords equal on the two sides were observed. These continued for about two minutes. The excursions of the previously immobile vocal cord gradually diminished in extent as the asphyxia passed off and then ceased.

It is not feasible to repeat this experiment frequently in the monkey with the object of getting the immobile vocal cord to work naturally.

LEONTIASIS OSSEA.

By R. LAWFORD KNAGGS, London.

GENERAL OBSERVATIONS

THE expression 'leontiasis ossea' has been used to designate those cases of hyperostosis of the skull whose nature was not understood. Originally leontiasis was a descriptive term of great antiquity applied to cases of leprosy in which a rough scamed and thickened condition about the mouth suggested the muzzle of a lion. The appearance was produced by deposits of new material beneath the skin which gradually increased and coalesced until the entire face was changed into a hard mass with a deeply scamed and roughened surface almost obliterating the features and sometimes closing the eyes (Stann) *.

When Virchow suggested its use in cases of hyperostosis of the skull he had in mind another form of 'leontiasis' in which masses of new connective tissue developed in the skin or in the subcutaneous tissue—a progressive hyperplasia of pre-existing connective tissue (fibroma molluscum—elephantiasis molluscum). He believed that the overgrowth of bone in hyperostosis corresponded exactly to elephantiasis of the soft parts, and he decided to call these cases leontiasis ossea, not because the bone disease produced a leonine appearance but because he considered it to be analogous to a disease of the soft parts which did (VIRCHOW, *Pathology of Tumours*, French translation, Arnhonsson, ii, 22).

Leontiasis ossea, if no longer a descriptive title is at least a comprehensive one. But as the different forms of disease which it has hitherto included are gradually shown to possess a separate identity they must of necessity be distinguished by more appropriate names. If the skull of Bickersteth's case which is recorded by Murchison (*see Fig 245*) be compared with the 'Bristol' skull described by Stack (*see Fig 246*), a striking difference is at once apparent. The former is evidently the subject of a very extensive and exaggerated plastic periostitis, and in the latter the affection is one of the medulla—an osteitis. In the first the disease has advanced gradually and persistently, in the second it was probably diffused throughout the whole skull from the beginning.

These two skulls are examples of two different diseases. They are extreme instances but there are many other cases of each form of disease in which only two or three bones, a single bone or even a portion of one, are involved.

The majority of cases of leontiasis ossea fall naturally into two groups —†

* For plates see Leloir, *On Leprosy*.

† A few recorded cases do not appear to fit readily into either of these categories, but these are for the most part clinical cases which do not appear to have come to a post-mortem and consequently have not been thoroughly worked out (STARR, *Amer Jour Med Sci*, 1894, cxiii, 680, HALL WHITE, *Brit Med Jour*, 1896, i, 1377) J. S. COLLIER (*Lancet*,

I *Cases of very chronic periostitis, spreading slowly from bone to bone, to which the title of Creeping Periostitis of the Bones of the Face and Skull may be given*

II *Cases of Diffuse Osteitis of the Bones of the Face and Skull* This may be (a) genical (b) circumscribed or (c) local. The last affecting the jaws is usually due to dental sepsis or irritation. Probably these are all instances of osteitis fibrosa.

I CREEPING PERIOSTITIS OF THE FACIAL AND CRANIAL BONES

The periostitic form of leontiasis ossea has two distinctive features. It is remarkable for (a) The great exuberance of the subperiosteal bony deposit, especially upon the facial bones and (b) The slow relentless way in which the inflammatory process creeps from bone to bone until after many years almost the whole skull may be involved.

In the attempt to elucidate the nature of the disease its characteristic features will be considered under the following heads:—

- 1 The origin of the disease in the nasal fossæ and its accessory sinuses
- 2 The paths and method of its extension
- 3 The changes in the nasal fossæ and accessory sinuses
- 4 The complications
- 5 The histology and morbid anatomy
- 6 The pathogenesis
- 7 Cases historical, clinical, pathological

1 The Origin of the Disease in the Nasal Fossæ and its Accessory Sinuses—There can be no question that the disease begins in almost all cases in the nasal fossæ or the sinuses. In early cases the fossæ may be blocked with bone growth and extension on to the face only just beginning.

The superior maxillæ, which enclose the fossæ, and whose cavities communicate with them, are the first bones to show visible enlargement for the disease spreads in the first instance to their external surface when once it

1901, 1, 20) subsequently gave the termination of Hile White's case. The head of the patient had been noticed to enlarge after a fall from a window upon his head at the age of 4 years. At the post-mortem—following an operation—the skull was found to be thin, and the deformity to be due to a fold or plexus in the vault, no doubt resulting from the injury many years before. The posterior two thirds of the vault had been telescoped on to the base by pressure from above. The specimen is in the pathological department of the Queen Square Hospital for the Paralyzed.

The work of Baumgarten (*La Leontiasis Ossea*, 1892) on this subject should be mentioned. I have been unable to obtain his monograph, but give the following extract from Starr's paper: "Baumgarten has made a careful study of this condition described by Virchow, and has collected descriptions of all these skulls in various museums of Europe. He has shown that some present a uniform thickening of all the bones, whilst others have shown an enlargement limited to the bones of the face, the cranium escaping. He points out that the latter class of skulls probably belonged to patients suffering from the disease acromegalia in which, as is well known, the bones of the face are very markedly enlarged. He considers that the pathological changes present are either a thickening of the surface of the bone alone or a change both in the surface and the diploc, the latter being transformed in some cases into a spongy tissue, in others into a hard substance like ivory. He admits that the literature does not contain any description of this disease during life, and does not think that cures have been observed."

emerges from the anterior nares. In some instances the disease is almost limited to these bones and in advanced cases they show greater deformity than any others. Nor must it be overlooked that the antrum of Highmore and the teeth are two anatomical features well known to be predisposed to inflammatory troubles. The evidence of museum specimens however places the nasal fossæ and the sinuses under much greater suspicion than the teeth and even in the worst cases the alveolar regions are often seen to have escaped altogether.

2 The Paths and Method of the Extension of the Disease—The most probable cause of the periostitis is a micro-organism. The infection travels on the deep surface of the periosteum, and the inflammation which it sets up in that membrane is accompanied by an osteitis of the adjacent bony tissue.

As already stated, the inflammation begins in most cases in the nasal fossæ or one of the an sinuses and after involving both fossæ it emerges in front and behind. On the face it spreads over the front of the maxilla, often sparing the alveolar processes, and reaches the frontal bones along the frontal processes. Diffusing widely over that bone, it reaches the parietals, and then the occipital. Laterally it may spread to the malar bones or pass beneath them round the external surfaces of both upper jaws towards the pterygopalatine fossæ. Posteriorly it escapes by the sphenopalatine foramen into the pterygopalatine fossa and advances thence in two directions. In one the stream of new periosteal bone passes round the posterior surface of the superior maxilla to merge with that already described as passing backwards below the malar bones, in the other it passes upon the great wing of the sphenoid into the temporal fossa and joins that covering the frontal bone.

The orbits are apt to be invaded from four points. (a) From the upper jaw over the inferior orbital margin. (b) From the frontal bone over the superior orbital margin, (c) From the pterygopalatine fossa by way of the sphenomaxillary fissure over either the superior maxilla or the sphenoid, and (d) Up the nasal duct.

The arch of the palate may be reached through the anterior and posterior palatine canals, and its posterior portion formed by the palate bone is often much less affected than the maxillary part.

It may appear difficult to explain the implication of the mandible by direct extension, but it probably takes place by way of the buccinator muscle and the pterygomandibular ligament, for it is the outer surface, close to the insertion of these structures, that is the first part to enlarge (*Case 11*). Moreover, in *Case 7* (Bickersteth's) the disease, having involved the whole of the ascending ramus, has travelled back to the skull, evidently along the temporomandibular joint ligaments, and attacked the mastoid region on the right side (see *Fig 245*). The very unusual affection of the hyoid bone in this latter case must be similarly explained, the mylohyoid muscles probably constituting the bridge. The only instance in which dissemination by the blood-stream can be suspected occurred in the same case in the left fibula thirteen years after the commencement of the disease on the face.

The general plan of extension is very largely influenced by the attachments of the periosteum. Where that membrane dips between adjacent bone at the suture lines the inflammatory process is held up for some time. The

periostitic bony deposit accumulates and forms a heaped up bulging and sometimes almost overhanging edge. At last the attached periosteum is penetrated here and there by the infection and invasion of the surface of the adjacent bone begins at two or three points. The power of other attached membranes such as the temporal fascia or the palpebral ligament to prevent for a time the coalescence of approaching streams of osseous lava is beautifully demonstrated in occasional cases (*Fig 241*)

Sutures tend to become buried beneath the periostitic deposit when once the adjoining bone is attacked but even in the late stages deep sulci in the osseous covering mark their situation. Nowhere are these facts more obvious than in the orbit, where bulging prominences contrast with smooth normal surfaces and all are exactly mapped out by the sutures (*Fig 241*)

3 The Changes in the Nasal Fossæ and Accessory Sinuses—A knowledge of the way in which the disease advances makes it possible to realize the process that goes on within the nasal fossæ where the mischief starts.

The infection probably penetrates the mucoperiosteal lining of one of the an sinuses and after spreading beneath the periosteum around the cavity passes through its bony orifice and involves the corresponding nasal fossa. It must be understood that it spreads between the periosteum and the bone. When once the septum is reached no difficulty is likely to be experienced in its extension to the opposite side. From the fossæ the periostitis spreads into a variable number of the sinuses and leads to their gradual obliteration by periosteal deposits on their walls. Sometimes the remains of a sinus may be revealed in a section of the bone as a linear tract running to the natural exit (*Case 12*), in other cases the obliteration may be complete. The thickness of the new deposit of bone can sometimes be recognized.

The sinuses most often attacked are the maxillary antra, the frontal and the sphenoidal, but the ethmoidal cells less commonly. Nearly always the corresponding sinuses on both sides are involved, and it may be very difficult to be sure in which one the disease started.

The obvious implication of one side of the face before the other or a more advanced condition of disease on one side is often seen and indicates a unilateral origin. Only in one case (Sir Astley Cooper's, *Case 3*) has there been evidence of disease of a single sinus other than that just described.

The osseous deformations in the nasal fossæ themselves are usually extreme. The floor, the sides, the roof, the turbinate bones and the septum all participate, and the fossæ, when viewed from the anterior or posterior apertures, appear blocked by bony masses which fit together like parts of a jig-saw puzzle. The vomer may be nearly an inch in width and the turbinate bones changed into sessile bosses. The identity of the inferior may sometimes be proved by a dimple on its under surface marking the opening of the nasal duct, whilst that canal is apparently obliterated in its length.

4 The Complications—It is quite certain that one of the earliest signs must be nasal obstruction. It will usually be present to some extent before any deformity is recognized. The deformity however seems to have absorbed the general attention, and nasal obstruction is only occasionally alluded to in the clinical accounts (*Cases 2 and 8*).

Trouble with the lachrymal apparatus from stenosis or obliteration of the

nasal duct is also to be expected. It is occasionally mentioned and because it occurred before any deformity appeared it has in two cases been looked upon as the exciting cause of the disease (*Cases 2 and 3*)

A remarkable condition of the left frontal sinus is presented in the macerated specimen of Sir Astley Cooper's case (*Case 3*). The walls of the sinus have enlarged towards the centre in three rounded masses leaving the cavity represented by a triadate cleft. The mucous lining must have been constricted in the middle and an hour-glass shape given to its interior. The two lateral globular portions have evidently become distended. The lower one has eroded by its pressure the orbital roof and the upper one has raised up the floor of the anterior fossa of the skull and also eroded it. This has produced a circular chimney half an inch high three-quarters of an inch in diameter and open at the top. Its wall is formed by the abrupt raising up of the thin compact tissue of the fossa. Through this chimney the osseous arrangement in the interior can be examined. There is no evidence of suppuration and it is probable that the condition was caused by an interference with the drainage of the cavity—that it was a consequence of the disease and not an exciting cause (*St Thomas's Hosp. Museum No 610*).

That the eyes must suffer is clear. Proptosis and exophthalmos are frequently mentioned, and blindness is often present in the late stages. This may result from corneal ulceration and perforation (*Case 5*) from compression by bony outgrowths, or from traumatic rupture of the exposed globe (*Case 3*) but the stretching of the optic nerves or pressure upon them in their course may result in optic atrophy and failing vision.

The occurrence of mental or cerebral disturbance in these cases would not be astonishing in view of the great vascularity of the diseased bones in close relation to the anterior lobes. Some signs of these are met with in the sparse clinical records. Thus the pugilist (*Case 5*) had occasional symptoms of insanity in the last two years and died from an effusion of blood beneath the cerebral arachnoid. Young's case (*Case 9*) was three times in an asylum but not until after the swellings appeared. He had hallucinations of sight and hearing, and died of syncope during exertion in connection with one of them. There was in this case a family taint, for one sister died in a lunatic asylum.

A girl 6 years old came under my observation at the very beginning of the maxillary hyperostosis. When 11 she began to have 'fits' of an uncertain nature, and a skiagraph showed that the anterior part of the base was affected as well as the frontal bone and mandible. She died at the age of 25 in the Leeds Union Infirmary where "her fits became more frequent and severe, and her mental condition, never very bright, gradually deteriorated."

Bickersteth's case (*Case 7*) died of coma without any very evident cause, and Astley Cooper's patient, whose frontal sinus has just been described, was seized with a fit which seemed to be of an apoplectic nature and died almost immediately in St Thomas's Hospital.

Suppuration and necrosis is an extremely rare complication, and is no doubt due to a secondary infection, *Case 13* is an instance.

5 **Histology and Morbid Anatomy**—When the enlarged bones are sawn across they are found to be composed of a closely cancellous bone which extends

through both the original bone and the periostitic deposit. There is no outer layer of compact tissue, but the summits of botryoidal protuberances may be slightly polished and the surface is perforated by innumerable apertures for small vessels. The original bone has been involved in a secondary extension of the superficial inflammation so that its limits can seldom be detected, and then only vaguely. In the lower jaw of the Peruvian's skull (*Case 4*) traces of the original compact tissue are to be seen on the face of a sagittal section buried in a mass of new bone. The character of the bone in these cases was investigated by a Committee of the Pathological Society appointed to report on Bickersteth's specimens (*Case 7*).

The tumour on the fibula was carefully examined. "The great mass of the tumour was made up of dense ivory-like bone with here and there an extremely delicate cancellous structure. The dense bone was very tough and to the naked eye appeared compact at first view but on closer examination was seen to be studded with numerous minute openings. The microscopic appearances were peculiar. The compact tissue was traversed in every direction by large branching and communicating vascular channels forming in some cases a close network. At the point of confluence of these canals there was often a sort of ampulla. From the sides of the larger canals finer ones were given off which formed communications with those coming off from the neighbouring or even from distant large ones. The spaces between the canals were filled up by bone tissue of ordinary character. There was an indistinct lamination for the most part parallel to the walls of the canals. The lacunæ were in general very numerous but they were small and for the most part elongated. The majority were furnished with very delicate canaliculi. Very few traces of Haversian systems were to be seen. The cancellated bone presented for the most part the ordinary characters but even here were found many of the large canals running into the cancelli." The composition of the bone was practically normal.

The Committee also examined a section from the Peruvian's lower jaw (*Case 4*). This presented characters identical with those observed in the fibular tumour. They concluded that "the structure of the cranial bones in that case (*Case 7*) was the same as the fibula" but they did not examine them for fear of injuring the specimen. An illustration of the microscopic appearance was given with the report (*Trans. Pathol. Soc. Lond.*, vol. 250, plate 12).

6 Pathogenesis of Creeping Periostitis—There is no bacteriological proof that creeping periostitis is due to micro-organisms but no recorded observations on this point have been found. The suggestion that it is of micro-organic origin is based upon the curious way in which the disease spreads which can only be explained by a living infection. Its nasal origin, too, lends the idea some support. The infection must clearly be one of low virulence and capable of long duration and it does not cause suppuration. The infection responsible for serious periostitis and serious osteitis in the long bones has these characters, and in those cases in which it causes "necrosis of the compact tissue without suppuration" it is possible to trace another resemblance in its slow progressive extension beneath the periosteum.

There is good reason to believe that the organism in serious periostitis is a staphylococcus of attenuated virulence and in the absence of any definite

micro-organic findings in creeping periostitis it is perhaps permissible to point out these similarities though great differences are only too obvious.

But how is the profuse deposit of periosteal bone which characterizes the creeping affection of the skull bones to be explained? In the only case in which a long bone was affected, the same or even a greater exaggeration of new bone formation was observed. Are we to suppose that this is the way in which a hitherto unrecognized organism manifests its presence or can we look upon it as due to some peculiar idiosyncrasy on the part of the bone-forming tissues of occasional individuals resulting in this unusual response to an infection which is not unfamiliar to us? These questions cannot be answered yet.

7 Cases Historical, Clinical, Pathological—

Case 1 —MALPIGHI The first reference to this disease is found in the *Opera Posthuma* of Malpighi (1700 A.D.) One of his observations (p. 68) describes a skull in the treasury (collection?) of the Most Serene Duke of Modena. It weighed 10 Bononian (Bologna) pounds, i.e., 120 oz. and was without the lower jaw. The description, in Latin, is quaint and somewhat difficult to follow but it is quite clear that the specimen was an example of the periostitic form of leontiasis ossea producing marked deformity of the upper jaw, orbits, and cranial bones—a single old tooth was deeply fixed in its alveolus and the disease had spread to the first cervical vertebra.

Case 2 —FOURCADE'S
This is the first case with a

clinical history. An account of it is given by Vichow. Fourcade was a surgeon at Perpignan and had a son, who except for an attack of variola had enjoyed good health till he was 12 years of age (1734).

At this time his father opened for him near the inner canthus of the right eye a lachrymal tumour which suppurated for a very long time. There developed at the same time on the nasal apophysis of the right superior maxilla a tumour as big as an almond which grew till at the age of 15 it compressed the nasal cartilage in such a manner as to prevent the youth from breathing except by the mouth. The disease then extended to the inferior maxilla,



FIG. 239.—Fourcade's case. View of the complete skull
(After Lebert)
For the two photographs of this case I am indebted to
Mr. H. E. Powell.

which kept its normal form only at the articular extremities and alveolar borders. The superior maxilla, the walls of the orbits with the exception of the roofs, the nasal openings, the palate and malar bones were invaded and enlarged till they formed shapeless masses. At 20 years of age the face was monstrous. He had exophthalmos with myopia, difficulty in speaking, and general enfeeblement.

He died, blind and phthisical, at the age of 45. The macerated head

weighed 8 lb 4 oz, the inferior maxilla alone 3 lb 3 oz (Figs 239-240). Great tuberos and lobulated exostoses having the density of marble protruded from the lower jaw and inferior borders of the orbits; the cranial bones were thickened with little smooth, and completely sclerosed excrescences. The frontal and maxillary sinuses had entirely disappeared. The rest of the skeleton was remarkable for the fragility of the bones (VIRCHOW, *Pathology of Tumours*, French trans. Anthonsson,



FIG. 240.—Fourcade's case. The lower jaw from above. The grooves for the facial arteries are very conspicuous (After Lebert).

11, 20. LEBERT, *Traité d'Anat. Pathol.*, plates 32 and 33).

Case 3.—SIR ASTLEY COOPER'S Specimen in St Thomas's Hospital Museum, No. 610.

The upper jaws are the chief seat of the mischief. Rounded bosses project forward $1\frac{1}{2}$ to 2 in. from the anterior surface of each bone above the unaffected alveolar processes. Different sections made through the specimen show each antrum to be obliterated by the growth, which encroaches also on the nasal fossæ. The frontal and ethmoidal sinuses are similarly obliterated. The very unusual condition presented by the left frontal sinus has already been described on page 351. The nose is difficult to examine and the condition of the posterior part of the fossæ does not appear to be so exaggerated as in many cases. The specimen was taken from a Billingsgate fishwoman long remarkable for her hideous appearance. Two large swellings had grown under the orbits in the forepart of the cheeks between which the nose appeared wedged and the nostrils closed. Each eye projected considerably from its socket. The lower jaw was not affected. The manner of her death is described above (page 351). (COOPER and TRAVERS, *Surgical Essays*, Part I, 171.)

Case 4.—The skull of a Peruvian in the R.C.S. Museum No. 1358, Gen. Path. Sect., is evidently an old one. It has often been referred to by writers on leontiasis. There is no known history attached to it, but it is a very



FIG 241—The Peruvian skull—no history (R C S Museum No 1358 1, Gen Path Sect.) The illustration shows how the attachments of the periosteum to the sutures, and of the temporal fascia to the temporal ridge have limited temporarily the extension of the periostitis. In the orbit the different bosses are exactly limited to the surfaces of various bones forming that cavity. The right ascending ramus of the mandible is seen to be severely affected.

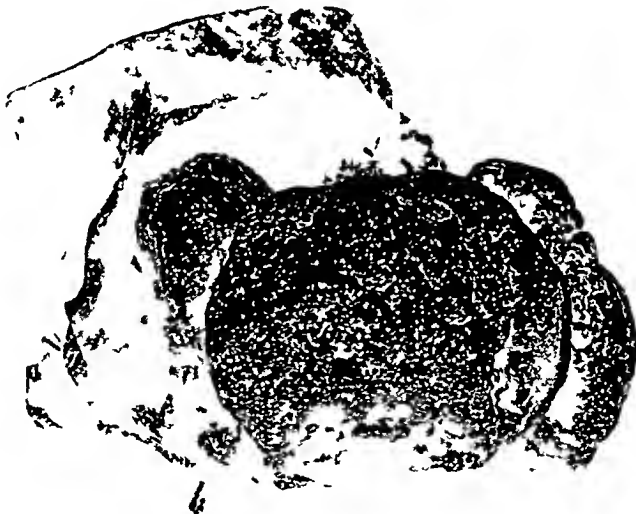


FIG 242—Antero lateral view of the pugilist's skull, Howship's case (R C S Museum No 1377 1, Gen Path Sect.) The intra orbital boss and the large facial tumour arise from the maxilla. The groove between them shows the influence of the palpebral ligament and the suture between the maxilla and malar bone. The malar bone is only slightly involved but the osseous stream passes below it to the posterior surface of the maxilla.

instructive specimen, because the peculiarities of the extension of the disease can be so easily studied upon it (*Fig 241*)

Case 5 — Pugilist's skull in RCS Museum No 13571, Gen Path Sect

This is another example of immense rounded bosses jutting forward from the front of the superior maxilla (*Fig 242*) The posterior nares show solid turbinate bones fitting into a much swollen septum The sphenoidal sinuses are filled up with bone and the frontal sinuses are obliterated (*Fig 243*) The conditions are more advanced on the left side Both the orbits are practically filled up with exostoses The specimen is described in Sir James



Fig 243—Posterior view of the specimen from Howship's case. A coronal section has passed through the sphenoidal sinuses. It shows the effect of the disease on the nasal fossae and the sphenoidal sinuses, the osseous growth fills the pterygomaxillary fossa, extending into the orbit, and blending below the malar bone with the facial mass. (A) Left orbit opened up showing bone outgrowth within. (B) Obliterated sphenoidal sinuses. (C C) Malar bones—temporal processes. (D) Left inferior turbinate bone. (E) Pterygoid fossa. (F) Left middle turbinate bone. (G G) Right and left hamular processes. (H) Vomer. (I) Right inferior turbinate bone. The shadow above and to its left suggests a cavity. The shadow, however, is part of the vomer, which leaves only a chunk to represent the right nasal fossa. (J J) Teeth. The hard palate, between looking down and backwards. (K) Bony mass protruding from pterygomaxillary fossa, passing up into the orbit and down beneath the malar bone to coalesce with the outgrowth on the face.

Paget's *Lectures on Surgical Pathology* (11th ed 535). In spite of some discrepancies there can be no doubt that it is derived from a living case described by Howship (*Observations in Surgery* 1816, Case 9 p 26, with portrait—*Fig 244*). Le Dentu in referring to Howship's case, gives the same catalogue number as Paget. The clinical history is interesting.

The subject was a man about 60 years of age who believed the disease began eighteen years before death in consequence of repeated blows received in the face through fighting. The first symptom was the very sudden onset

of inflammation in both eyes which evidently ended in double lachrymal abscess. This occurred fourteen years before Houslip saw him in 1811. After some months, osseous swellings formed below each orbit. Later one eye suppurated, its cornea sloughed and it shrivelled, and the other when it was protruded and lying upon the hard tumour in the cheek was struck by part of an iron bedstead he was handling and burst.

In 1815 the patient was in good health. The tumours were not tender on pressure. They appeared to occupy the whole space of each orbit as well as the cavities of the nostrils which were almost obliterated. There were varicose veins in the skin covering the swellings. The history of occasional insanity and the cause of death have been given above (page 351).

Case 6—A specimen (No 397, St Bart's Hosp Museum old No 162) quoted by Paget in his *Lectures*.

The superior maxillæ are not much enlarged or deformed on the facial aspect, but the nasal septum and lateral walls are much thickened, and the antia with the frontal and sphenoidal sinuses are greatly diminished or almost occluded. The specimen is of interest

because it shows early invasion of the anterior surfaces from the nasal fossæ, and from the orbits through the infra-orbital canals—a patch of periosteal deposit being present below each foramen. A similar invasion of the oral palate by way of the palatine foramina is also to be seen, but is much less evident. There are no clinical details.

Case 7—BICKLESTETH'S. This case is fully recorded by Dr Murchison in the *Pathological Society's Transactions* for 1866, xvii, 243.

The specimen is in the Museum of the Liverpool Royal Infirmary, and casts of it are in the R C S Museum the Middlesex Hospital, and the Leeds Medical School (*Fig 245*). An illustration of the patient is given in the *Liverpool Med-Chir Jour* 1857, i, 264.

The patient was 34 years old when he died, in 1857. At the age of 14 the bones of the face were first noticed to be enlarged. Three years later he was an in-patient at St Thomas's Hospital for this enlargement. The swelling gradually increased and thirteen years after its commencement a similar hard swelling appeared along the course of the left fibula. Apart from the



FIG 244.—Portrait of the patient in Case 5
(After Houslip.)

unsightliness, the swellings caused the patient little inconvenience until two years before his death when he began to suffer intense pain in the leg and pain, less severe in the head. He became gradually emaciated, and as the facial enlargement increased, the cavities of the mouth and nose were greatly lessened, and the eyeballs protruded even beyond the lids. The sight of the right eye remained good, but that of the left was lost.



FIG. 245.—From a cast of the skull of Bielcrsteth's case (RCS Museum No 13591 Gen Path Sect.) The photograph was taken to show that the disease has spread from the lower jaw back to the skull. An isolated area of periostitic deposit is seen on the otherwise normal temporal bone in immediate relation to the temporomandibular joint.

The mobility of the lower jaw was but slightly interfered with and mastication and deglutition were performed without difficulty. Smell and hearing were not affected and the intellect was unimpaired. In the end he became suddenly comatose without evident cause and died. Death was attributed to exhaustion, emaciation, and protracted suffering. At the post-mortem the internal organs generally appeared healthy. The patient had never suffered from syphilis, and there was no history of tubercle or constitutional syphilis or cancer in the family. A brother had a similar enlargement affecting one upper jaw which began about the age of puberty, but had remained stationary for many years.

In addition to the enormous deformity of the skull and lower jaw, which is very

like that in Fourcade's case the hyoid bone was also affected. The tumour of the fibula, whose cross-section measured $5\frac{1}{2}$ in. by $4\frac{3}{4}$ in., sprang from the posterior and inner surface of that bone by a narrow neck (determined by fascial attachments?) and it may be noted that it showed a canal on its inner side evidently for a vessel of considerable size. Its characters have already been described (page 352). Part of this tumour is in the Middlesex Hospital Museum (C 133).

Case 8.—Of five cases of leontiasis ossea recorded by Victor Horsley (*Practitioner* 1895, iv, 1), his third case is the only instance of the periostitic variety. It had a very interesting history.

The early part is given by Bland-Sutton (*Trans Clin Soc* 1889, xii, 266). A man, age 24, came under his care in the Middlesex Hospital in September 1888. He was five feet high and appeared to be stunted by rickets. Five

years before a swelling had appeared in the neighbourhood of the nose without any known cause. Two months later the right ascending ramus of the lower jaw became affected, and gradually the face became deformed by the projecting masses on each side of the nose. The swellings caused no pain but gave rise to inconvenience from nasal obstruction. On Oct 3 1888, the affected part of the right lower jaw, which had increased rapidly of late, was removed subperiosteally (i.e., the portion posterior to the 2nd molar). At the patient's request the right upper jaw was removed on Oct 20—an operation justified by the complete obstruction of the right nostril, some proptosis of the right eye, and failing vision (R.E.V. = $\frac{1}{16}$, J 16).

In 1890 he came under Holsley's care. The left side of the face was becoming enlarged and he often had neuralgic pain. There was only perception of light in the right eye, whilst the sight of the left was failing, and the disc was atrophic. Holsley's operation ended in a simple exploration as he was not permitted to remove the upper jaw, which was the only treatment likely to benefit.

The illustration in the Clinical Society's *Transactions* shows that this was a well-marked case of the periostitic form of leontiasis ossea. In the upper jaw the antrum was obliterated and the thickening involved all parts of the bone alike.

As the failure of vision advanced after his operation, Bland-Sutton concluded that the optic nerves were undergoing slow compression in their passage through the sphenoidal bone.

Case 9—JAMES YOUNG, Bristol, recorded the following case (*Brit Med Jour*, 1896 Oct 31, 1803).

The patient was 39 when the disease first appeared, and no cause could be assigned by him or his friends. The upper jaws were thickened generally and the protruded masses on them were tender. There was distinct prominence and thickening of the supra-orbital ridges, more marked on the right side, and also exophthalmos and ectropion. His mental condition has been described on p 351. He died at the age of 46. Post mortem the frontal sinuses and antra were occluded, and the orbital cavities diminished. The nasal cavity was filled right up by encroachments of bosses of bone on each side. The right superior maxilla was considerably thickened along its alveolar margin. The bosses of bone protruding from the upper jaws were found on section to be cancellous in structure. The kidneys were granular.

Case 10—Specimen in St Mary's Hosp Museum, No 9172, from a dissecting-room subject. No clinical notes.

In this instance the frontal and sphenoidal bones are more severely affected than the others. The malar, superior maxillary, and nasal bones are involved to a considerable degree by extension but both antra persist.

The frontal bone is greatly thickened, being one inch or more thick in places at the section through the brow. The frontal sinuses are completely filled and the whole section shows a dense, finely porous surface with no differentiation of either table. The signs of involvement of the sphenoid are unusually marked. Rounded masses correspond to its orbital surfaces, and the periosteal deposit can be traced through the sphenomaxillary fissures to the temporal surfaces of the great wings. The interior structure of the right

wing is exposed and is dense like that of the frontal bone whilst the intracranial aspect of the whole bone is particularly marked by numerous vascular foramina. There is also considerable deposit of periosteal bone in the nasal fossæ, but the blockage is not so complete as that seen in many of the previous cases. It seems probable that the focus of trouble lay in the frontal and sphenoidal sinuses and that infection spread chiefly from the posterior part of the fossæ to the orbits which show extensive changes.

It is not easy to trace the path to the frontal bone. It may have been, and probably was, by way of the orbits and assisted by the direct tracks made by the vessels and nerves. The infection has emerged at the anterior openings of the nasal fossæ but this was probably only a late development and the well-advanced condition on the vault can hardly have originated from it.

Another peculiarity of this specimen is the presence of two or three apparently isolated patches of periostitis near the parieto-occipital suture, but there are slight signs that this isolation is not quite so decided as it seems to be at the first impression.

Case 11—DR LLDIARD. This specimen (R C S Museum 13611 Gen Path Sect) a portion of a lower jaw, is valuable because it shows the first part of that bone to become involved.

It was removed from a woman age 45 in 1902. Bony prominences had existed on each side of the bridge of the nose for 20 years. They originated in the superior maxilla, and gave the face a frog-like appearance. They had become stationary. The enlargement of the lower jaw had been noted for three months and showed evidence of activity. The patient died after the operation.

The enlargement extends from the symphysis to the angle and affects chiefly the outer aspect and lower border. It is evidently the result of periosteal deposit, for the original body of the jaw can still be recognized vaguely in the cross-section though it blends with the new bone. All the molars and premolars are absent and the alveolar process and the tooth sockets have disappeared.

Case 12—No 398, St Bartholomew's Hospital Museum is "a superior maxillary bone in which the cavity of the antrum is completely filled up by a growth of porous or very finely cancellous bone. The cavity is represented by a linear track opening into the middle meatus. There is periosteal deposit on the external and orbital surfaces, and also on the posterior surface traceable from the pterygopalatine fossa. The lateral nasal wall is considerably affected, and the nasal duct opening is represented on the under surface of the bulging formed by the altered inferior turbinate bone. The antrum was probably the focus of the disease in this case. It was from a girl, age 15 years. Enlargement of the nasal process of the superior maxilla had been observed for eight months and was increasing. The disease was painless and the general health good. Death occurred from erysipelas ten days after removal of the upper jaw' (See STANLEY, *Treatise on Diseases of Bones*, 297).

Case 13—No 399, St Bartholomew's Hospital Museum consists of portions of a superior maxillary bone which before division formed a nearly spherical mass of hard, heavy, and cancellated bone. There is no smooth surface on any part of the various portions to suggest an exostosis.

It was taken from a man age 37. A smooth prominence of the nasal process of the right superior maxilla had been noticed for two years but it was not increasing. He was admitted with what appeared to be necrosis of the alveolar portion of the jaw and suppuration around it. After four months the mass of the bone which occupied the position of the antrum completely separated and was removed. The cavity, which opened widely into the mouth and nose, gradually contracted and the man recovered. This case is described in Sir James Paget's *Lectures on Surgical Pathology* (old catalogue No. 1260).

There is insufficient evidence to assign this case to the periostitic or the osteitic group but it no doubt belongs to one or the other.* It is quoted here to show that septic infection may complicate these cases on rare occasions.

II DIFFUSE OSTEITIS OF THE BONES OF THE FACE AND SKULL

(*Osteitis Fibrosa*)

This form of leontiasis ossea results from a peculiar inflammatory affection of the medulla (i.e., the soft tissues occupying the cancellous and diploë spaces and Haversian canals) and has certain very distinctive features—

1 *The Complete Absence of any Periosteal Bone Deposit*—This is the most striking feature and the one which distinguishes it at once from the other variety—namely, creeping periostitis.

2 *The Character of the Change in the Shape of the Affected Bone*—It is enlarged, often enormously, but the enlargement gives the impression that the bone is swollen. The resemblance to the normal bone remains but the salient points that give the latter its 'expression' disappear. The bulky bone distends its periosteal envelope so that its fossæ are filled up, and sharp ridges and elevations are rounded off. The suggestion is conveyed that the change of shape must have depended upon an alteration in the consistency and firmness of the osseous tissue.

3 *The Osseous Tissue presents Definite Characters*—The bone, especially in the early stages, is vascular and soft. In the cranial bones vascularity is very noticeable. If the bone is exposed during an operation the hæmorrhagic colour and mottling are conspicuous beneath a thin or perforated surface, and indicate the extent of the morbid process.

When this appearance is present the bone is very soft and can be cut or gouged away, or penetrated with a trephine without any trouble. In the later stages when ossification has advanced considerably, the bone becomes firmer but even in the 'Bristol' skull it was stated to be 'markedly' softer than normal.

The surface of the bone is smooth, but it does not present the smoothness and polish of compact bone. When carefully examined it is seen to present innumerable apertures, but there are areas where these are much less in evidence. Such areas are the remains of the compact tissue, whose absorption is brought about from within (*see Fig. 249*). The innumerable apertures

* In the Atlas (1877-79) of the Musée Dupuytren, plate 41, there is an illustration of a skull showing a marked degree of the periostitic form of leontiasis ossea. Its number is 384—Professor Cruveilhier's specimen.

represent the surface of a cancellous tissue of new formation, which has taken the place of the original bone (compact—cancellous—diploë), and is permeated by a vascular connective or fibrous tissue medulla which blends with the periosteum. The foramina certainly transmit vessels, but they are filled with this soft tissue as well.

The appearance produced by this change on the surface of the bone has been likened to that of coarse woollen cloth and it is well shown in the photograph of the lower jaw of the 'Bristol' skull. Little buds of osteogenic tissue, which is what the medullary tissue has now become, protruding from these apertures, may ossify and when this happens a very finely mammillated surface results which might easily be mistaken for periosteal deposit.

The cranial bones may be enormously thickened. The width of a cross section has amounted to 3 in. The inner and outer tables (or in other bones the compact surface) cannot be differentiated, and the face of the section is composed of finely porous bone of varying degrees of density and of similar character to that exposed superficially by the disappearance of the compact tissue. The homogeneous aspect of the section may be interrupted by some scattered patches or tracts of soft fibrous-looking material and in rare instances cystic degeneration of such a patch may be seen.

In the 'Bristol' skull where the disease was of many years' duration, patches of very dense bone, and spaces from which soft tissue has been removed by maceration and from which softened contents escaped after the bone was divided are dotted about in the general expanse of cancellous tissue of varying degrees of density. This appearance points to an ossification which has been irregular in its incidence of long duration in some parts and much shorter in others, and it may be compared with unmacerated specimens in which fibrous patches are present in a mass of osseous tissue of uneven density (*Case 12, see Fig 254*).

† *Age of Onset*—The age at which the disease first manifests itself is usually in the first or second decade of life. The disease is clearly one of young people, and the exceptions are met with more commonly in those cases in which the jaws are primarily involved as a consequence of dental irritation (*Group C*).

Cases of the osteitic form of leontiasis ossea fall into three definite groups—

Group A—A general diffuse osteitis of the cranial and facial bones

Group B—A circumscribed osteitis of one or more cranial bones or of a part of one

Group C—An osteitis beginning in one or both jaws and rarely spreading far beyond them. This group is associated with dental irritation in most cases.

Group A—GENERAL DIFFUSE OSTEITIS OF THE CRANIAL AND FACIAL BONES

Instances of this remarkable affection are not numerous.

Case 1—The following description of a skull in the Museum of the Bristol Royal Infirmary (No 141) is taken from an article by Stack who recorded the case in the *Bristol Med-Chir Jour*, 1900, xviii, 316 (*Figs 246-249*). The patient's photograph represents her with a very prominent overhanging



FIG. 246—The Bristol' skull Showing the smooth surface and persisting sutures

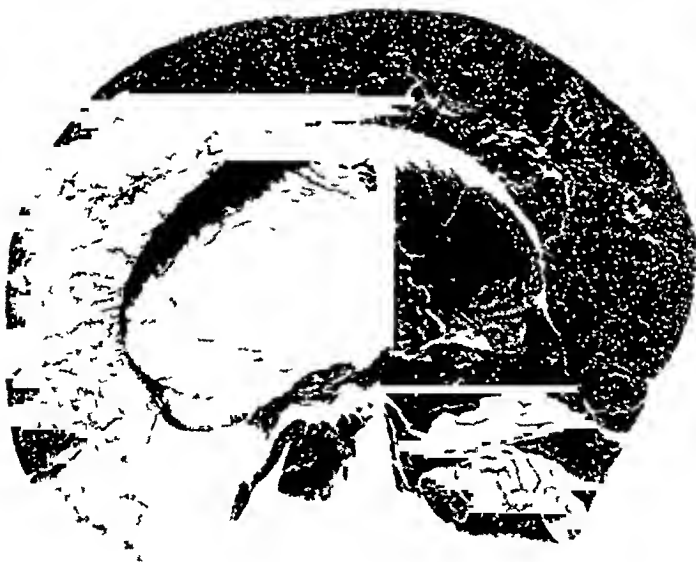


FIG. 247—The Bristol skull sagittal section With a magnifying glass the persistent fronto ethmoidal and parieto occipital sutures can be seen

forehead and an enormous protruding lower jaw. Though the facial bones were affected, the face itself appears insignificant between these two marked deformities. The half skull without the lower jaw weighed $7\frac{1}{2}$ lb., and the lower jaw 1 lb.

There was enormous thickening of the vault and base, and this attained its maximum in the cerebellar region, where the width of the section was 3 in. The outer surface was quite smooth and the internal fairly normal. The bones of the skull were for the most part markedly softer than normal, but the appearance of the section was not quite homogeneous. In parts there



FIG. 248—The 'Bristol' skull front view. Showing the diminished orbit and absence of the alveolar process.



FIG. 249—The 'Bristol' skull lower jaw. Showing the patches of compact bone contrasting with the darker coarser woollen cloth appearance where the surface is porous and also the eroded opening into the hollowed portion of the interior.

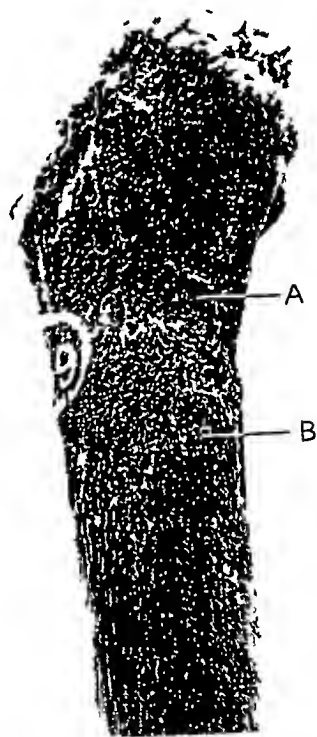


FIG. 250—The upper portion of the right tibia of the Bristol case. Showing a part (A B) where the compact surface has been eroded from within. With a magnifying glass a much better idea of the condition can be obtained.

were masses of more compact tissue, and in others there was rarefaction to such an extent as to leave spaces of $\frac{1}{8}$ in diameter. The lower jaw had a

few temporary teeth (age 21) on its upper surface where the alveolar ridge had been. The body was enlarged and rounded and the compact shell expanded and filled with very porous bone containing a quantity of slimy gummy material which poured out when the bone was cut into. Several of the permanent teeth were buried in the under surface of the bone quite on its lower aspect.

Notable changes were also present in some other bones. The pelvis was generally contracted and markedly beaked and twisted the sacrum being deflected to the right. There was slight scoliosis, but the vertebrae and ribs were normal in consistency. The femora were slightly bent and softer than natural. The right tibia was bent laterally chiefly at the lower end of the upper third and there was also a slight anteroposterior curve of the whole bone, the outer face of the upper articular surface sloped downwards and outwards, and a marked genu valgum had been present on this side.

CLINICAL HISTORY—The patient a female, age 21 was admitted to the Bristol Royal Infirmary under Dr. Waldo in December 1899 for sore throat and dyspnoea, and died the same night.

When 3 years old she fell, cutting her forehead, and was in the General Infirmary for several weeks. At 7 the mother first noticed the child's head to be larger than natural. At 12 she had the right canaliculus slit up for dacryocystitis. At 19 she fractured the lower end of the right femur, which united in two months. The mother thought the lower-jaw deformity began at the same time as that of the head. Mentally she was all right, and a great help to her mother though she tired too easily to be of use in the housework. She never had any fits, and there was no sign of syphilis in either parent or in other children. She died from diphtheria after tracheotomy and the dyspnoea was in part due to a firm fibrosarcoma containing numerous giant cells which grew from the posterior surface of the hard and soft palate.*

* Having made recently a careful examination of the preserved and mounted bones from this case in the Museum of the Bristol Royal Infirmary, I can now give the following additional details.

No. 141, *Left Half of the Skull—Sagittal Section*—The outer surface (*Fig. 246*) is smooth with a certain amount of tracery upon it, partly from periosteal vessels, partly from papillary mammillated hemispherical points (mustard seed). This papillary condition is present particularly over the lower part of the frontal bone and over the surface of the temporal fossa and anterior part of the mastoid process. It suggests small bulgings of medullary tissue (osteogenic) through thinned and perforated compact tissue which have subsequently ossified. There is no sign of them being due to periosteal deposit—indeed, on the face of the cross section an external table can hardly be considered to be present.

The inner surface of the skull (*Fig. 247*) is also smooth, but not polished, and shows no sign of periostitis, the internal grooves are deeper than normal and sharply defined. The bony canal for the middle meningeal artery is very marked. The jugular foramen is considerably contracted, apparently by expansion of the bones which form it, and a considerable foramen, evidently for an emissary vein of large size is situated in the floor of the lateral sinus groove and opens on the under surface of the occipitomastoid suture. It suggests an established collateral venous circulation. Other foramina are but little altered if at all. The lateral sinus groove is very indistinctly marked. The whole body of the sphenoid bone is enlarged and the pituitary fossa is very shallow. The petrous part of the temporal bone is the least changed of all the bones.

The following additional particulars may be added. Occipitofrontal circumference 31½ in., suboccipital circumference 30¾ in. In Sir James Paget's case of osteitis deformans

Case 2—The Jadelot—or the Sacy—skull (*Figs 251-252*) can be traced back to 1745. It was found at the village of Sacy near Rheims 15 feet deep in the ground. In 1799 Jadelot gave a full description of it, and this is reproduced in part by Paul Gevaux in an article on “Hyperostosis in Man and Animals” (*Jour. de Zoologie*, 1875, iv 272). The specimen is in the anthropological section of the National Museum of Natural History, Rue de Buffon, Paris.

Presumably the skull only was found for it was taken for a giant's until

the circumference at the level of the middle of the temporal fossa was 26 $\frac{1}{2}$ in. That of an average skull is 21 in.

The Sutures—The squamous portion of the temporal bone is markedly affected, bulging externally, whilst the squamospetrous suture marks the bottom of a considerable depression with sloping sides. The occipitoparietal suture is also well marked, and can be traced across the surface of the section into the suture on the interior of the skull. The coronal suture is well seen, but cannot be traced across the section. The suture between the lesser wing of the sphenoid and the orbital plate of the frontal bone is separated (apparently in maceration). The nasal bone shines in the general enlargement, and the sutures in connection with it are clearly seen on the section and on the face.

The Air Sinuses—There is no trace of the frontal. The bone in its situation is minutely porous, and passes gradually above into irregular spaces with here and there patches of dense bone of various size. The sphenoidal sinuses are only represented by irregular spaces in a mass of porous bone. There is no compact lining to these spaces, but rarefied cancellous tissue projects into them. The part below the pituitary fossa is completely filled up.

The Orbit—The edges are rounded and smooth. The walls are smooth, but show similar tracery to that on the vault. It is contracted in its circumference but increased in depth. The sphenoidal fissure, the optic foramen, and the sphenomaxillary fissure are of good size, but the latter is more deeply placed in the orbit than normal, owing to the hypertrophy of the maxillary bone. The nasal duct is doubtfully obliterated.

The Jaws—The upper jaw is enlarged. The alveolar process has disappeared (*Fig 248*). The palatal plates of this bone and the palate bone are nearly 1 inch thick, and show two cavities for teeth displaced towards the nasal floor. The pterygoid plates of the sphenoid are enlarged and fused with the palate bone and the hollows are filled up.

The body of the lower jaw (*Fig 249*) forms a large rounded swelling much bigger on the left side. The enlargement diminishes in the ascending ramus and shades off into the coronoid processes. The condyles and necks are practically normal. The specimen is somewhat crumbled, and there is a considerable cavity in the left side of the body having eroded openings in front and behind. The boundaries of this cavity are formed of irregular and rarefied bone which is elastic when compressed. Opening on the under surface are three cystic cavities—probably associated with teeth. The compact surface of the bone has disappeared except for thin patches on triangles, and the porous rarefied bone exposed gives the coarse woollen cloth appearance. There is no sign of periosteal deposit. A cross section through half the width of the body has been made. This shows a very fine cancellated structure throughout, except in the central part of the bone where the spaces are larger.

The Right Tibia (No 249)—Some details have been given in the text. In addition it should be noted that the compact tissue has been thinned and eroded in many places (*Fig 250*). These appear as roughened areas, but with a magnifying glass they are seen to have been produced by absorption of the compact tissue and the exposure or formation of a finely reticulated cancellous tissue, and not by a deposit of periosteal bone. The most marked portions are situated on the inner and posterior surfaces of the upper fifth, and in the lower half in patches on the posterior and external surfaces.

Necropsy—The body was ill nourished and suggested an age of 14 or so instead of 21. The brain was normal and weighed 47 oz. All the other organs were healthy in appearance except (1) The liver, which showed on its surface several small growths scarcely larger than tubercles, and in its interior a few larger ones, the largest of which was as big as a small marble. These showed the same microscopic structure as the liver tissue, namely, fatty infiltration with diffuse cirrhosis—a condition that raised the question of congenital syphilis. (2) The right thyroid lobe contained a mass which resembled exophthalmic goitre in its microscopic structure. (3) The myeloid sarcoma springing from the hard palate has been referred to (P.M. Book 16, p. 36).

Jadelot showed from its dentition that it was that of a child of only 5 or 6 years of age. Though the greater part of the teeth are missing the alveoli

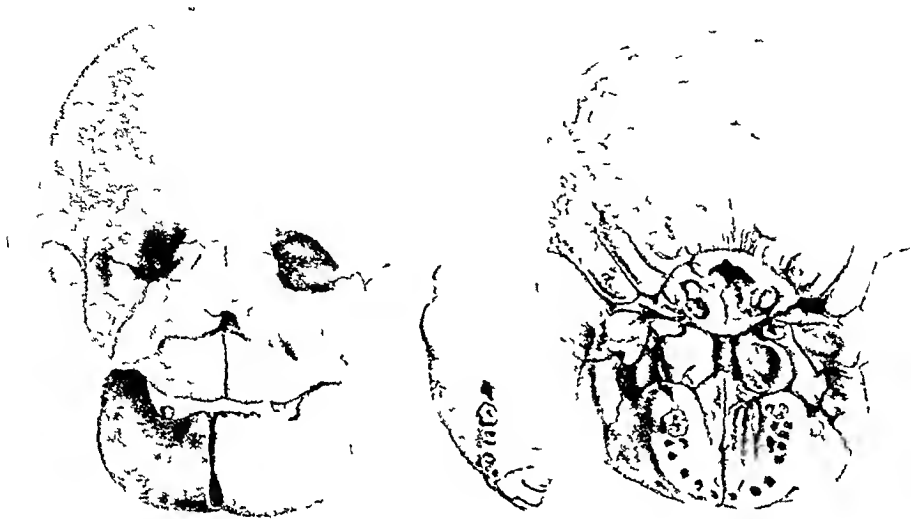


FIG. 251 — The Jadelot or Sacy skull (After Gervais)

pointed to 20 milk teeth and 4 permanent molars. Jadelot's conclusion, however, cannot be implicitly accepted, for fibrous osteitis, which I believe to be the explanation of these cases, when it affects the jaws, plays havoc with the dental arrangements.

Jadelot and Gervais believed that the other bones were affected, but this is evidently pure assumption. If they were as in the Bristol case, it is almost certain that they were not hypertrophied. The cranial bones are stated to have attained an extraordinary thickness.

The drawings which accompany Gervais's paper show that the exterior of the skull had a smooth surface like that of the Bristol skull, but on the internal surface of the base the bones presented a

swollen appearance which modified the foramina and especially the foramen



FIG. 252 — The Jadelot or Sacy skull (After Gervais)

magnum. A horizontal section showed that the cranial walls were everywhere thickened. This thickening amounted to as much as 3.5 cm. or more. At the occiput it was 3 cm. on each side of the frontal bone 2.5 cm. and at the vertex 3 cm. The thickened walls are said to have preserved in part then diploë structure.

From the measurements of a cast of the brain cavity Gervais deduced that the brain exceeded the average ordinary dimensions in the adult and that the child in addition to the hyperostosed skull, was also to a certain degree hydrocephalic (loc. cit. p. 161). The presence of Wormian bones might be considered to have lent a little support to this idea.

A microscopical account is also given and the bone is stated to have had a very different structure from that of healthy osseous tissue. From the description it would appear that the bone trabeculae were not laminated, that they were formed from fibrous tissue and that the bone cells were not stellate. This is evidently very similar to the new bone formation in osteitis fibrosa.

Case 3—This is recorded by Ilg (*Einige anatomische Beobachtungen* Prag 1821).

Barbara Rudolf was one of eight living healthy children whose father died at the age of 30 from consumption and the mother at 60 with dropsy. In her 10th year she began to suffer from headache and epilepsy. She became deaf in both ears at 16 and from that time her head was noticed to be getting bigger and she had difficulty in lifting it. From her 17th year she was unable to take solid food, and about the same time outward curvature of the leg bones developed. She suffered from loss of smell, became bad-tempered and imbecile, was confined to bed and died suddenly in her 27th year.

Ilg's drawings show the base of the skull to be almost a facsimile of the base of the Jadelot skull, and the outer surface of the vault and face to have the same even surface whilst the cross section of the vault was enormously thickened. (*See also PACET Med. Chir. Trans. 1862*.)

Case 4—Dr. Shore has drawn my attention to the cast of a head in St. Bartholomew's Hospital Museum (Casts No. 1).

Its resemblance to the 'Bristol' and the Jadelot skulls is so exact that there can be no doubt it was taken from a skull affected by the same disease. Unfortunately nothing is known about the case from which it was taken.*

What is the nature of the disease in this group? With the removal of all the soft tissue by maceration it must be largely a matter of inference. There are, however, certain facts to help us. (1) The original bone evidently has disappeared and the hyperostosis is produced by a new formation. (2) In

* In the Atlas of the Musée Dupuytren for 1842 there are four illustrations of a skull, which is almost certainly another instance of the osteitic form of leontiasis ossea. The whole cranium is affected and the foramen magnum is much deformed. A description is given in the catalogue accompanying the atlas, under No. 378. It was from a man, age 65 years, of small stature and good intelligence, who had always had a head so large that he could not find a hat to fit. The rest of the skeleton presented no abnormality. The hypertrophy was limited to the cranium and did not extend to the face. This led M. Andral, who presented the specimen, to suggest that it might exemplify a method of cure in hydrocephalus. Husehke, in an article on "Crimo sclerosis totalis Rhachetici" (Jen., 1858), gives four plates representing a cranium with a left parietal bone showing the smooth surface and thickening seen in the 'Bristol' and Jadelot skulls.

this new formation it is clear that the ossifying process is irregular both in distribution and in point of time (3) Putting the irregularity of ossification side by side with the uniform thickening of the bone, it is evident that an intermediary tissue is formed as the old bone vanishes and before the new bone forms, and that it is in this intermediary tissue that ossification proceeds.

In the succeeding groups it will be seen that there is no question that the disease is osteitis fibrosa, and there can be hardly any doubt that this is the form of osteitis which is responsible for the general diffuse affection. The features just mentioned are those of osteitis fibrosa, and the inference is supported by the alterations present in the other bones of the 'Bristol case' and by the microscopical appearances of the bone in the Sac skull.

Group B—CIRCUMSCRIBED OSTEITIS OF ONE OR MORE CRANIAL BONES

This form usually begins as a localized swelling shading off into the normal bone. It gradually invades the whole bone and it may, if not interfered with, spread beyond it and involve adjacent bones. The connection of this group with osteitis fibrosa is quite definite, and in one instance the cranial manifestation was only part of the generalized form of that disease.

Case 5—In my Hunterian lecture on osteitis fibrosa (*Brit Jour Surg* 1923 v. 487) I have described a case that came under my care in the Leeds General Infirmary. A girl, age about 16 years, had a swelling on the frontal bone which was so small that its removal was accomplished by a trephine with a very large circle. This cut through the bone with the greatest ease. The microscopical characters were those of osteitis fibrosa.

Of the five cases recorded by Horsley in the *Practitioner* (1895 iv, 12) one has already been given amongst the cases of 'creeping periostitis'. The other four are probably all cases of osteitis fibrosa, but only two (Horsley's 2nd and 5th cases) were examined histologically.

Case 6 (Horsley's 2nd case)—E.C., age 26, was admitted with a swelling on the left side of her head near the middle line in front of the coronal suture. It had been coming on for about five years and was not painful at first, but latterly had caused some pain of a shooting character over the vertex. It was removed on May 26 1888. The dura was laid bare over an area as big as a shilling. Recurrence followed, and on April 9, 1894, the tumour was again exposed. The bone forming it was highly vascular, and its limits could be defined by the increased vascularity. The whole of the disease was cut away by a trephine and bone forceps.

Case 7 (Horsley's 5th case)—H.D., age 35, was admitted to University College Hospital on March 18, 1895, with a swelling on the right side of his forehead. Fourteen years before he fell from a tree, and the next day a swelling appeared over the right eye with redness and pain, and was said to be erysipelas. It subsided in a week. Though he did not remember striking his head he attributed the swelling to the fall, but a photograph showed that growth had begun at least three years previously. It occupied the whole right frontal region. The orbital margin was thickened and the tumour could be felt pressing the eye downwards and this was also somewhat protruded.

On April 24 1895, the tumour was removed by an extensive operation which included the cutting away of the major part of the great wing of the sphenoid and the upper part of the malar bone. The surface of the tumour was smooth and the bone vascular. The bone was softer than natural and its thickest part was at the margin of the orbit, where it measured $1\frac{1}{4}$ in. The roof of the orbit was much thickened and the frontal sinus was obliterated.

Horsley pointed out that in every case (1) the outer surface of the swelling was smooth, (2) the diseased bone presented a marked contrast to the normal, being notably more vascular and having its surface pitted with minute foramina the branching of the superficial vessels being very prominent, and the colour a deep red as compared with the pink white of normal bone, (3) on section of the whole thickness there was no demarcation between tables and diploe, but the appearance was uniform, and (4) the medullary spaces appeared to be filled with a soft tissue but yielded no marrow pulp.

The histological details are clearly of the same kind as those in osteitis fibrosa.

Of the medullary tissue it is stated that in the outer portions of the tumour it consisted chiefly of a delicate fibrous tissue. From this to one in which the whole medulla was converted into a dense feltwork of fibrous reticular substance, every stage could be found. The bony trabecula showed notable changes as soon as the medullary tissue became obviously altered until in the most advanced areas of disease every bony trabecula showed a marked reversion to a chondroid stage and the margins and surfaces displayed many false Howship's lacunae. At the periphery the trabeculae were normal and the lamellae were well marked.

The naked-eye features and interior of these tumours correspond closely with those noted in *Case 5*.

Case 8—A fourth instance occurred in the same patient from whom those specimens were obtained which enabled von Recklinghausen to establish the identity of osteitis fibrosa. It is an important case, linking up as it does, leontiasis ossea with osteitis fibrosa. The hyperostosis of the skull met with in that case is thus described.

"The head was lop-sided because the right occipital region was thicker than the left. The bone was 2 cm. thick here, but the skull was in general thin. Externally the surface could be indented by the finger. A section of the bone at this point was hollow. The cavity, like others near it, was surrounded by compact hard bone. It was filled partly with watery fluid and partly with white soft fibrous tissue which lay in the middle of the space and sent processes to the smooth wall of the cyst" (*Vnchow's Festschrift Assistenten*, p. 6).

It is a curious coincidence that Vnchow who showed the bones from this case at the 59th Congress of the Deutscher Naturforscher und Aerzte in 1886, drew attention to the Sacy cranium described by Geivais in 1875, though it does not appear that he appreciated the true nature of the disease (*Deutscher naturforscher Sammlung*, 1886, Gen. Path. and Path. Anat. Sect., p. 307).

The circumscribed form, when it affects the cranial bones, usually begins in the frontal and is often limited to it when the case first comes up for

treatment, but occasionally the disease may attack and be limited to one of the other bones *

Case 9—Thus, Virchow illustrates a dense though lightly porous hyperostosis of the whole of the left half of the sphenoid which was found in a woman, age 35, who died of typhus and had slight exophthalmos (*Pathology of Tumours* French translation, II, 20)

Case 10—This case was shown to me by Mr Barrington-Ward at Great Ormond Street Children's Hospital. It was a boy of 6½ years, in whom the first signs of cranial disease were noticed in May, 1921. An enlargement of the left temporal bone developed and was thought to be sarcomatous. It was explored in February, 1922, and a piece removed for examination. In October, 1923, there was proptosis and also slight bosses on the frontal and parietal bones on the right side. The left inferior maxilla was affected. Skiagrams showed discrete rarefied patches in most of the long bones, on the left side chiefly, and these were particularly numerous in the bones of the hand and wrist. Some diminution in the temporal swelling had followed the insertion of radium.

Through Mr Barrington-Ward's kindness I am able to show a microscopic section from the piece of tissue removed from the temporal bone (*Fig 253*). It is typical of osteitis fibrosa, but is chiefly intended to show the connection of the hyperostosed skulls of *Group A* with osteitis fibrosa.



Fig 253—*Case 10*. The section is only slightly magnified ($\times 17$) so that as much as possible of it is brought into the field. It shows a continuous layer of bone of new formation in which irregular lacunae filled with connective tissue or fibrous marrow are evenly distributed. Ossification has advanced beyond the stage of separate trabeculae, and is still in progress at the edge of the lacunae. In the illustration the latter are partially bounded by white lines caused by shrinkage. With a magnifying glass the structure of the bone and the marrow can be made out. It is easy to understand from this case and section how the thick hyperostosed skulls of *Group A* develop in osteitis fibrosa. (Mr Barrington Ward's case. Photomicrograph by Dr G. H. Rodman.)

* The ancient parietal bone (R. C. S. Museum, No. 693) found in Hunter's collection of fossils has usually been attributed to osteitis deformans. A careful examination, however, makes this doubtful. The bone is complete, and its four borders present well-marked sutural surfaces. It is reasonable to suppose that the bone was separated in its entirety from its connections by natural processes, and not by art or violence. In all probability it is the parietal bone of an individual who was too young to be the subject of osteitis deformans, and it is impossible to believe that it could have separated from a skull affected with that disease, in which the sutures of the vault are generally obliterated. There is

*Group C—OSTEITIS BEGINNING IN ONE OR BOTH JAWS AND RARELY
SPREADING FAR BEYOND*

The importance of this group lies in the fact that most of the cases are, or have been associated with dental suppuration or irritation, and there can be no doubt that this had a great deal to do with the production of the disease.

The affection presents different aspects in the two jaws. The superior maxilla are usually converted into masses of more or less solid bone but in the mandible the disease presents a greater resemblance to that in the long bones. Large cavities are often present in the enormously expanded jaw lined with very delicate cancellous bone. These cavities before maceration were no doubt filled either with fluid from degeneration of the fibrous tissue, or with fibrous tissue in which ossification was so little advanced that no bony trabeculae-work remained when the soft tissue came away during maceration.

The following cases will illustrate these statements.

Case 11—The specimen (St. Bart's Hosp. Museum No. 100b) was taken from a woman, age 38, who had noticed her upper jaw enlarged for twelve months. Some decayed teeth had been extracted three weeks before the operation. It is "a right upper jaw which has been sawn across to show its involvement in a dense bony mass which chiefly occupies the alveolar margin but extends up to the antrum and the floor of the nasal cavity which both seem quite healthy. On the face of the section a few small fibrous patches can be detected here and there and the largest patch is situated around the site of one of the extracted teeth."

Under the microscope "the tissue of the growth resembles dense cancellous bone, the spaces being occupied by fibrous tissue with some mucoid degeneration."

But in the next case the whole superior maxilla on the left side was affected, and the disease had spread to the opposite bone along the alveolar process and encroached upon the right antrum.

Case 12—The specimen (R.C.S. Museum 1360.2 Gen. Path. Sect.) is a left upper jaw whose antrum is completely obliterated (*Fig. 251*). It is

much less difficult in looking upon it as an instance of the osteitic form of leontiasis ossium (osteitis fibrosa). Separation of a sinus during maceration is mentioned in the note giving a detailed examination of the 'Bristol' skull (*Case 1*).

In Horsley's other cases the frontal bone was also the chief seat of the disease.

Horsley's 1st case—S.M., age 19, had some severe illness eight years before, nature unknown. Four years before had senile fever, and shortly after noticed his head bulging. From the age of 14 he had generalized epileptic fits three or four times a year. There was pain which became diffused as the swelling increased, and in the early stages vomiting occurred with the headache. The right ear was deaf (the temporal bone was affected), and there was obvious downward deviation of the eyes from the projection of the growth into the orbits. No operation.

Horsley's 4th case—A female, age 13 years, had a swelling of the left frontal region six months, it became painful one month before admission. There was double vision some time before the swelling was noticed. It was removed with the whole breadth of the orbital roof which was affected. A year later no further enlargement had taken place.

Keen's case (*Internat. Clinics*, 9th Ser. II, 180)—A girl, age 10. Six years before, the left eye became inflamed and gave considerable trouble. Shortly after, swelling was noticed in the frontal region above that eye. As it increased the eyeball was pushed downwards and optic neuritis developed. At the operation the skull was found enormously thickened (3 cm.) and so soft that it could easily be gnawed away with forceps or shaved off with a scalpel.

obviously an example of osteitis fibrosa. An anteroposterior section has been made through the bone, and the outer half is shown. The enlarged bone bulges roundly in front at the side and behind, but not towards the orbit. The face of the section is composed of dense, finely porous bone. Fibrous areas or tracts are numerous, and some are more or less sharply margined. In the alveolar region the bone and fibrous tissue are more evenly blended and the bone spaces are larger than elsewhere and of a deeper colour, as if more vascular. In the anterior part of this region a patch is undergoing cystic degeneration, its margin and septa being fibrotic. The 2nd molar is half destroyed by caries, but there is no sign of pyorrhœa.

The microscopical examination of one of the fibrous patches "showed it to consist of bundles of cellular connective tissue the closeness of which varies. In it there are well-formed capillaries and capillary arterioles with a single layer of circular muscular fibres."

The jaw was removed from a youth, age 19 years, in May 1919. He had noticed a small hard swelling of the left cheek two years before. There was no pain and no discharge. Carious teeth (1st and 2nd premolar and 1st molar) were extracted in February 1918, and he attributed the trouble to this. For four months before removal the swelling had rapidly increased and was accompanied by epiphora on the same side.

There are various macerated specimens of the upper jaw in different museums, in which an enlarged bone shows a section of finely porous osseous tissue extending to the surface, and an obliterated or diminished antrum. All tell-tale evidence of fibrous tissue, if any existed, has been removed by maceration, but the face of the section often shows spaces which are either artefacts, or may have been filled with fibrous material.

Case 13—An upper jaw in the Leeds Medical School Museum (old No A 64 new No A 84) is of this type. The bone is much heavier than normal. Its grooves and fossæ have been to a great extent obliterated by the increase in thickness and density of all parts of the bone. Pyorrhœa has no doubt existed for the 2nd molar is carious, and there is a trench around the other two molars in the alveolar border which contrasts with the normal in-setting of the other teeth.

Case 14—A very similar specimen to which Lord Lister's name is attached, is in the R C S Museum, Gen Path Sect 1360 1. It is a left superior maxilla



FIG 254—*Case 12* (R C S Museum, No 1360 2 Gen Path Sect) Section through the upper jaw showing its transformation into a dense porous osseous mass, in which are scattered masses of fibrous tissue one of which in the lower part is undergoing cystic degeneration.

with part of the palate bone which was removed by operation. The alveolar process and body have developed into a finely porous bony mass forming a smooth prominence on the outer surface. The flattened antium is widely separated from the roots of the molar and bicuspid teeth and its cavity lies against the thin normal outer wall of the nasal fossa. The 2nd bicuspid is carious, but there is no evidence of pyorrhoea, and the dental origin of the condition seems doubtful.

Case 15—The following specimen was removed from a boy, age 11 years, who had noticed a swelling for two years. It is a dried right superior maxilla in which the antium is obliterated, but the wall of the nasal fossa is normal and smooth. The outer surface is smooth except where its compact layer has been converted to finely porous bone like that displayed by a section through the specimen.

In connection with a root of the carious 1st molar there is an abscess cavity which has perforated on the anterior surface of the alveolar process.

It is stated that "the tumour under the microscope showed the ordinary structure of cancellous bone" (St Bart's Hosp Museum, No 400 a).

Case 16—The dental origin of the disease is not at all clear in the following. The specimen (St Bart's Hosp Museum, No 400) is described as "a dense osseous tumour involving the whole of the left superior maxillary bone", and was removed from a boy, age 9. The teeth present are healthy. The surface of the bone is smooth and there is no differentiation of compact tissue from the dense porous structure of the interior. The antium is obliterated, but there are two or three small patches or streaks of fibrous tissue which are suggestive of the nature of the disease.



FIG 255—Photograph of the patient in Case 17

The lower jaw is much less frequently involved than the upper in this circumscribed form of the disease. But when it is, there is a great difference in the amount of new osseous formation in its interior and the relative enlargement of the bone is greater.

The enlarged and partially excavated lower jaw of the 'Bristol' skull (see Fig 249) is a good example, and another is furnished by the lower jaw of an ape in the R C S Museum No 711 V. Both these specimens are macerated and show the very delicate character of the new bone trabeculae.

Case 17—There is an unmacerated specimen in the Leeds Medical School Museum (No A 51 a) which is worth a more detailed description. Its histology is illustrated in a previous article on osteitis fibrosa (*Brit Jour Surg*, v 494, Figs 400-2). The specimen itself is described in the catalogue as an "enormous central tumour involving the greater portion of the body of the lower jaw. The chief protrusion is outwards, where the outer shell of bone has been

completely absorbed. The tumour on section is hard, dense, and gritty, has a fibrous structure, and shows some signs of laminae arranged in concentric whorls. There are four back teeth on the right side which seem sound, but on the left side the last molar is carious.

The tumour was removed by Mr. Littlewood, in 1895, from a man aged 34 years, who had had a gradually increasing swelling of the mandible for fourteen or fifteen years (*Fig 255*). An early photograph showed that it must have started near the symphysis. It was the only bone affected, and death followed the operation. Although it was originally regarded as an endosteal fibroma, recent histological investigation has shown it to be *ostertis fibrosa*.

Case 18—In 1920 an elderly looking man, age 62, was shown to me by Sn Frank Colyer. He had a massive enlargement of the mandible involving the whole body, including the whole tooth-bearing area, but leaving the angles and ascending ramus unaffected. The upper surface was rounded, and various teeth projected from it in a natural arrangement. There was a good deal of pyorrhoea, a probe passing down for quite half an inch alongside one tooth. In front of the body was a small area where fluctuation was obtainable through a thin pliable surface of bone. The alveolar processes of the superior maxilla were also much enlarged both on their outer and inner sides, and the roof of the mouth was transformed into an inverted-V-shaped arch. This condition had been developing for two years.

The shape of the cranium was remarkable. When seen sideways the frontal bone was much enlarged and elevated, and almost protruding, but the parietals did not share in the enlargement, and the skull shelved off into a normal shape behind the coronal suture. The skiagrams did not show thickening of the frontal bone, and this peculiar acrocephalic condition was thought by the patient to be natural to him. The temporal regions were unusually convex. This latter enlargement had not always been present, but he could give no help as to the date when it began. He was aware of the increasing size of his head because it became necessary to get larger hats.

He had a deviated nasal septum which blocked the left nostril, and had always been a mouth-breather. He was under treatment for deafness. The left clavicle was thicker than the right, but there was nothing else to raise a suspicion of *ostertis deformans*. He had never had syphilis. His general health was fairly good and he was quite able to carry on his work as a clerk.

Histology and Pathological Anatomy—The histology of this form of leontiasis ossea is the histology of *ostertis fibrosa*. The original bone disappears, and an area much larger than that occupied by it, but still limited by a periosteal investment is filled by a vascular and cellular connective tissue which in places or in some cases, may become fibrous. In this tissue new bone develops showing at any rate in the early stages no lamination, or a lamination produced differently from the ordinary lamination of bone (*see Fig 400, Brit Jour Surg* \ 494, from *Case 17*).

Its cells are rounded or triangular and not stellate like ordinary bone cells, and there are no regular Haversian systems. In some cases (*Case 5*) the new trabeculae exhibit a peculiar character. Well inside their margin there can be traced an outline suggesting that one trabecula fits into a bigger

one like parts of a jig-saw puzzle. This appearance would seem to be produced in this way. After the formation of a defined trabecula, there takes place a further metaplasia of the surrounding fibrous tissue into bone in some bulk and not slowly by the gradual incorporation of cells. The linear boundary of the older part of the trabecula, however, maintains its sharp distinction and cannot fail to attract attention.

A curious phenomenon was seen in an upper jaw case. Globules or pellets of lime salts stained deep blue with hæmatoxylin were present in a part where metaplasia of the connective tissue into bone was in its earliest

stage. The pellets were structureless, showed a tendency to cohere, and to become blended into a mass in which their globular outline was still visible. The connective tissue bounding such a mass would become condensed and take on the appearance of a trabecula with a pale blue stain. This exhibited the internal irregularities just described in which the influence of the conglomerated pellets could be detected. Such a trabecula might show at some part definite bone structure. In then mature form the trabecula showed the internal curvilinear tracery for which the globules were in part obviously responsible (*Fig 256*).

Probably the pellets represented the unabsorbed calcareous debris resulting from the destruction of the original



FIG 256.—Section from a portion of bone removed from an enlarged alveolar process of a maxilla resulting from septic teeth. It shows (1) a marrow composed of connective and fibrous tissue (2) metaplasia of this tissue to form bone, in which are included (3) numerous pellets of deeply stained lime salts.*

bone, otherwise we must suppose that there was some misordination in the stages of ossification, lime salts being delivered in mass before the connective-tissue cells had acquired the power of utilizing them in the usual way. Similar calcareous pellets have been described and illustrated by W. H. Dolamore in a case which reads very much like one of osteitis fibrosa of the mandible in a man aged 30 (*Proc Roy Soc Med* xiv, 1920-21 Section of Odontology p 14).

* The patient was a man, age about 40, in whom the disease, affecting both maxillæ, began in 1908. In 1919 he came under the care of Mr H. Watson Turner. The teeth were bad and there was severe pyorrhœa. There was swelling of the alveolar processes on the inner and outer sides which caused protrusion of the lips and teeth. The latter were removed, and in 1920 the hypertrophied bone external to the dental ridge was cut away. In 1922 the patient reported excellent progress, and the facial deformity as very much improved.

The Tendency for Diffuse Osseous Formation to Occur in the Cranial and Upper Jaw Bones—In the long bones affected by osteitis fibrosa there are usually considerable areas which to the naked eye are of a fibrous consistency and texture, though often gritty

In the Hunterian Lecture on osteitis fibrosa I have regarded the presence of these tracts as of great value in establishing the diagnosis. In the cranial and upper jaw bones, however, there is only small naked-eye evidence of fibrous areas. Small patches or narrow elongated tracts may be recognized in unmacerated specimens, but as a rule the new bone formation completely overshadows the fibrous tissue, consequently, when the disease has been limited to one upper jaw, the enlargement has often been regarded as an osteoma, and when the cranial bones have been the seat of the affection, they have been regarded as the subject of some mysterious form of hypertrophy.*

Whilst the difference is obvious it is not easy to explain it. It is possible that a better blood-supply may have some relation to the increased ossification. Thin bones with a vascular supply on each surface are probably better supplied with blood than a long bone whose interior is very largely dependent on that which comes to it through the nutrient artery. More blood would mean more toxins, and this might ensure a more rapid destructive effect upon the bone and would favour a more vigorous reaction.

When osteitis fibrosa is put forward as the explanation of such diffuse hyperostosis as is seen in the 'Bristol', the Sacy, and similar skulls (which it must not be forgotten have been macerated), there is a natural tendency to regard the suggestion with incredulity. But when it is remembered that in the upper jaw hyperostosis is the rule, and that in the cranium instances of the early and intermediate stages of hyperostosis are common and where microscopically investigated are usually shown to be due to osteitis fibrosa, it does not seem at all improbable that, when the disease is of long duration, such remarkable instances of hyperostosis should result.

In microscopical sections taken from the cranial bones a prominent feature is the even regularity with which the trabeculae are distributed, and the absence of large areas of connective tissue with few and scattered trabeculae.

The section from *Case 10, Fig 253* is instructive. The trabeculae have fused and are steadily growing at the expense of the intertrabecular marrow. It seems certain that if the process continues for any length of time, the greater part of the enlargement at present in being must be converted into a bony mass.

Pathogenesis—The periostitic form of leontiasis ossea is in all probability the result of micro-organic infection. The osteitic form is almost certainly caused by toxins.

In the Hunterian Lecture referred to the probable dependence of that condition upon toxic influence was discussed at some length. Consequently

* Thus Ziegler writes: "The phenomenon is not unnaturally accounted for by the assumption that in these particular instances the periosteum and the marrow possess an inherited predisposition to excessive osteogenesis" (*Special Path Anat*, English translation, Vol I, Sections 1 to 8 219).

there is little more to be said when it is recognized that the latter variety of leontiasis ossea is simply osteitis fibrosa affecting the cranial and facial bones.

The toxins which are responsible for such cases as those in *Groups A* and *B*, and possibly for some in *Group C* are probably carried to the part affected by the blood-stream. But in many cases in which the disease starts in the jaws (*Group C*) the toxins have almost certainly a local origin, and depend upon some septic trouble about the teeth. This is an important fact and points the way to prevention and possibly to cure.

In conclusion I desire to acknowledge with gratitude the courtesy and kindness extended to me by the Curators of the various museums from which I have been permitted to obtain material for this article. My thanks are also due to those friends who have shown me cases and allowed me to make use of them to others who have helped me and to Dr G. H. Rodman for the photomicrographs of two of the cases referred to. To Sir Arthur Keith and Professor Shattock I am under special obligation to the former for encouragement and helpful suggestion and to the latter for valuable direction for the readiness with which he has allowed me to discuss difficult points with him and for much kind help which it is unnecessary to particularize.

APPENDIX

The following museum specimens which are probably examples of osteitis fibrosa attacking the cranial and facial bones have been regarded with special interest because the nature of the disease producing them was uncertain.

Case 19—In St. Bart's Hosp. Museum (No. 75) is the skull of a child age 4 years who died of bronchitis. He was of defective intelligence and unable to walk. There was no evidence of syphilis in the child or its parents, and the other children were healthy. The disease was limited to the skull, the bones of the trunk and limbs being unaffected. The peculiarities of the skull are probably explained by the early age at which the affection must have developed. The following description is taken from the catalogue.

"The specimen shows great thickening of some of the membrane bones of the vault and of some of those of the face. The cranium is asymmetrical, being unduly prominent on the right side in front and on the left side behind. The sutures of the vault are synostosed. The calvarium is thickened every where, more in some regions than in others. Over the frontal and parietal eminences the thickness exceeds half an inch and the bones bulge externally. In the regions of the fontanelles and the sutures the thickening is less. There is thus some appearance externally of the condition described as Parrot's nodes. No distinction between the compact bone and the diploe can be discerned. The bones are uniformly dense and hard, though porous. Externally the surface is rough and pitted where the thickening is greatest—as over the parietal eminence—new periosteal bone having been deposited. (This pitted appearance is more probably the result of the changes occurring in the interior of the bone causing the substitution of porous bone for the normal external table.)

"The interparietal part of the occipital bone shares in the thickening which affects the membrane bones of the vault, the supra-occipital, like the other cartilage bones, is not thickened. The only membranous bones which have escaped are the squamosals. The thickening abruptly ceases at the squamosal suture. The cartilage bones of the basis cranii are not abnormal, the axis is not shortened, and there is no synostosis of the sphenoccipital synchondrosis. In the face the maxilla and superior maxillary bones are distinctly thickened and the inferior maxilla very much so, especially just in front of the angles.

"Dentition is natural" (All the milk teeth are present) "The microscopical examination of the affected bone shows the ordinary structure of cancellous bone but with widened canals."

In addition it should be noted that there is a rough carious state extending over the whole of the hard palate on its oral surface, which has opened the sockets of two healthy teeth. Evidently there existed for a long time some very unhealthy condition of the roof of the mouth which may have been responsible for the changes in the skull as well as for the child's generally unsatisfactory state. Neither rickets nor syphilis will explain the specimen, and there would seem to have been no evidence of either (*Group A*?)

Case 20—There is in the R C S Museum (No 711 V) the macerated skull of an elderly ape whose head had attracted attention for twelve years before he died. The hypertrophy is limited to the upper and lower jaws, and the frontal and parietal bones. The outer surface of the skull is smooth and porous and the inner like it, but the meningeal grooves are deepened. The sutures are obliterated on the vault but not at the base. The frontoparietal portion is about 1 in thick and the bone is of a uniform dense character showing no differentiation of inner or outer tables.

The bodies of both upper jaws form large rounded swellings, and teeth are seen embedded at the office of the healthy nasal fossae, and on the outer surfaces just below the maxilla bones. The alveolar processes have largely disappeared in front but support a single molar on each side at the back. The frontal sinuses have been filled in, but the antia and ethmoidal cells remain. The body of the lower jaw is much enlarged and rounded and its alveolar margin has largely disappeared. A molar tooth is present on each side and opposes the corresponding molar in the upper jaw. Several permanent teeth are seen enclosed in cystic spaces and a large empty space occupies the whole thickness of the jaw near the symphysis (*Group B* or *C*).

Case 21—Close to the last specimen in the Museum is the half of the unmacerated head of another ape (No 711 U). A fairly equal diffuse enlargement of the vault and base and upper jaw is present and the ramus as well as the body of the mandible is much swollen. The orbit is not encroached upon. There are patches of soft tissue (fibrotic?) dotted about on the face of the section in the cranial vault the nasal process of the superior maxilla the basisphenoid the basi-occipital and in the lower jaw and some are apparently undergoing disintegration (*Group A*).

*SHORT NOTES OF
RARE OR OBSCURE CASES*

**TWO CASES OF ACUTE INTESTINAL OBSTRUCTION
DUE TO IMPACTION OF GALL-STONES.**

By CECIL P G WAKELEY, LONDON

ALTHOUGH all the leading text-books on surgery mention impaction of gall-stones as one of the causes of intestinal obstruction it must be admitted that it is a rare condition. Two cases have recently occurred at King's College Hospital within six weeks of each other but during the past ten years no such case was seen at this hospital.

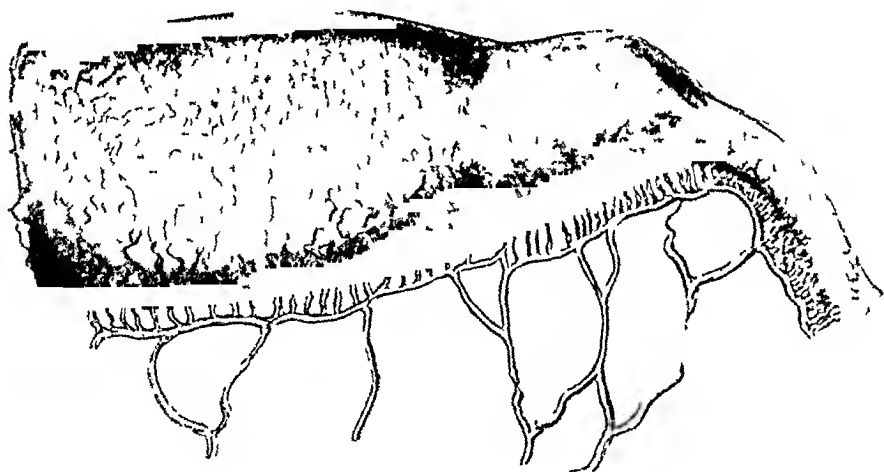


FIG. 257.—Case 1. Gall stone impacted in the small intestine.

Case 1—E. W., female, age 75, was seen on Feb. 1, 1923, complaining of abdominal pain and vomiting. She gave a history of faecal vomiting with abdominal colic and absolute constipation for three days; there was an indefinite history of chronic indigestion, culminating on one occasion with a similar attack thought to be due to gall-stones. On examination the abdomen was distended and the temperature subnormal, and she was kept under observation. The bowels were absolutely confined, but there was much less pain.

and no vomiting Thirty-six hours later the patient began to vomit material which was definitely faecal in character, operation was then decided upon

A median laparotomy was performed, as soon as the peritoneal cavity was opened, distended small intestine protruded through the wound A large gall-stone, subsequently found to weigh just under half an ounce, was felt in the lower end of the small intestine The stone was closely held by a ring of spasmodic contraction of the gut, above this the intestine was greatly distended, whilst below it was emptied and narrowed (*Fig 257*) The stone was pushed up the intestine for a short distance and then removed, the opening of the gut being closed by two layers of sutures The patient made an excellent recovery

This case is interesting in that the obstruction was not absolutely typical in its manifestations The faecal vomiting was intermittent, and the pain only severe when the vomiting was present These facts together with the actual finding of a ring of spasm gripping the stone, suggest that the intermission was due to the stone passing on for a distance becoming held up, and then passing on again



FIG 258—Gall stones from *Case 2* The one on the right was removed from the rectum, that on the left from the lower portion of the ileum (*Natural size*)

Case 2—M T female, age 55 was admitted to King's College Hospital on March 29 1923, suffering from intestinal obstruction The patient stated that she had been well most of her life, but had suffered from occasional giddy attacks during the last fifteen years She had had almost complete constipation for a fortnight She stated that she was always constipated, but never so bad as this On examination, the patient was found to be large and fat with an unhealthy complexion The skin was moist and cold The bowels were absolutely confined The abdominal wall was so fat that palpation was difficult, however there was marked resonance on percussion, general tenderness but no rigidity A soap enema was given with a small result and the passage of a little flatus On examining the rectum a large gall-stone was discovered too large to be passed naturally and so it was removed digitally The obstructive signs abated temporarily, and flatus was passed However after eighteen hours faecal vomiting recommenced with abdominal pain Operation was decided upon

A mid-line laparotomy was performed and a large gall-stone considerably bigger than the one which was removed from the rectum was found impacted in the lower end of the ileum about four feet from the ileocecal valve. There was great distention of the small intestine. The stone was removed and the intestine closed by two layers of sutures. It was found necessary to puncture the gut with a trocar and cannula before it could be replaced, the puncture was closed by means of a purse-string suture. The patient rallied after twenty-four hours but died three days after the operation from paralytic ileus.

At autopsy well-marked paralytic ileus was present. The gall-bladder was firmly adherent to the first part of the duodenum. On opening the duodenum two fistulous communications with the gall-bladder were found about 1 cm apart, the upper one was smaller and in all probability the stone which was removed from the rectum had ulcerated its way through it. The lower aperture was large and ragged and the bigger stone must have forced its way through it. The two gall-stones are shown in *Fig 258*.

I am indebted to my colleague Mr Arthur Edmunds for the notes on *Case 1* which was under his care, he also is responsible for the excellent coloured illustration.

A CASE OF INTESTINAL OBSTRUCTION IN A NEW-BORN INFANT, ASSOCIATED WITH AN UNUSUAL MALFORMATION OF THE SMALL INTESTINE

By T. TWISTINGTON HIGGINS, LONDON.

H. K. age 3 weeks, was admitted to the Hospital for Sick Children, Great Ormond Street, under the care of Dr Poynton on March 27, 1920. I am indebted to him for permission to publish these notes.

HISTORY—The child appeared to be normal at birth, but vomiting began immediately and continued without intermission. The bowels were constipated. On admission the child weighed 8 lb 3 oz, and appeared in very good condition. There was remarkably little wasting. The baby vomited constantly quantities of bile-stained fluid. There was no action of the bowels before operation. A tentative diagnosis of high intestinal obstruction was made, and Dr Poynton asked me to see the child with a view to laparotomy.

OPERATION—Under ether and oxygen anaesthesia the abdomen was opened to the right of the middle line. The stomach, duodenum and upper part of the jejunum were found to be markedly dilated, the remaining coils of small gut being collapsed. The terminal ileum and caecum were found entangled round the jejunum and lying to the left of the duodenojejunal junction. It required a slight pull to free them from this point, though it was never quite clear how they came to be fixed there. The most likely explanation would appear to be that the gut had become partially herniated into a peritoneal pouch in this region, but such a pouch was never clearly

demonstrable. The ascending colon possessed a complete and lengthy mesentery. Following upon the disentanglement, there was obvious relief of the obstruction, the coils previously collapsed becoming rapidly distended.

Further systematic examination then revealed the following condition: the jejunum, about 10 to 12 in. beyond the duodenojejunal flexure, tunnelled through the mesentery of the ileum some distance above its termination (*Fig 259*). There was no further obstruction at this point, the intestinal contents passing quite freely under the budge and it was therefore decided to leave well alone in view of the baby's condition. The abdomen was accordingly closed. The infant rallied from the operation satisfactorily and as soon as possible was put on to hourly feeds of equal parts of peptonized milk and water. The bowels began to act normally two days after the operation, and the vomiting did not recur. Subsequent recovery was uneventful, and the baby was sent home on April 20, having gained 8 oz. It has been seen from time to time since, has developed quite normally, and has no intestinal symptoms.

Comments — The nature of the obstruction in this case would appear to have been as follows. The ileocecal segment of the gut having become fixed in the upper abdomen, possibly by internal herniation, the lower pillar of the mesenteric 'bridge' (*Fig 259*) was dragged upon so as to produce an obstruction of the jejunum at the point where it passed beneath the 'bridge'. Release of the ileocecal segment relieved the obstruction. The complete and lengthy mesentery possessed by the

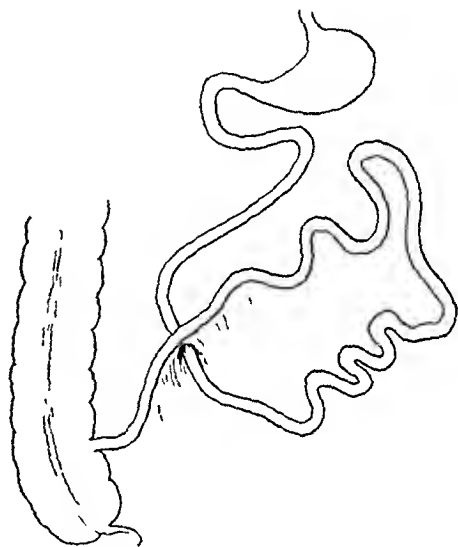


FIG 259—Diagram to show the position of the gut and mesentery

ascending colon permitted such a wide excursion as was involved. But the chief feature of interest about this case is the malformation of the small gut and its mesentery. I have been unable to find a record of any case illustrating a similar defect. The condition evidently represents a divergence from the usual mode of developmental rotation of the intestine. It would appear that two rotations have occurred: (1) The normal one whereby the colon comes to lie in front of the duodenum; (2) A second rotation in the same direction whereby the small bowel has become transposed in such a manner that the lower ileum bears a relation to the jejunum similar to that of the transverse colon to the duodenum.

Such an abnormality is not included in the list of possible variations cited by Sir Arthur Keith.¹ Bearing on this point he mentions: (1) Cases in which rotation does not occur at all; (2) Cases in which rotation occurs in a direction opposite to the normal. In the former the cecum lies on the left side of the abdomen and the ascending and descending colon is situated

behind and to the left of the small bowel. In the latter the duodenum and mesentery come to lie in front of the transverse colon in place of being situated behind it.

In the case here related the transverse colon was in its normal relationship to the duodenum, so that the primary rotation had pursued a normal course. A secondary rotation of similar type but affecting the small intestine alone, seems to be the only possible explanation of the malformation in this case. Such a developmental anomaly is evidently exceedingly rare.

REFERENCE

¹ KEITH, *Human Embryology and Morphology*, 4th ed., 300

SACCULITIS OF JEJUNUM ASSOCIATED WITH ACUTE INTESTINAL OBSTRUCTION DUE TO EMBOLUS IN AN INTESTINAL BRANCH OF THE SUPERIOR MESENTERIC ARTERY

BY A PINNIGER AND C. L. L. BURMAN, LADYSMITH, NATAL,
WITH A NOTE BY PROFESSOR CHARLES F. M. SAINT CAIR, TOWN

SACCULITIS of the large bowel is not of uncommon occurrence, but the condition arising in the first part of the small intestine in such a marked degree is of sufficient interest to warrant this case being placed on record.

HISTORY.—G. L., age 67, was admitted to hospital on Feb. 11, 1923, complaining of intermittent pain in the belly of an acute character, itching, and inability to pass flatus. The attack had come on suddenly in the early hours of the morning of Feb. 12, waking him up. He took castor oil which brought no relief, but at that time he only thought that he was suffering from one of the numerous bilious attacks to which he had been accustomed for the last twenty years. He sent for his doctor who saw him the same day and advised his admission to hospital, as he had passed no flatus and definite small-intestine peristalsis was evident, there was no rigidity or tenderness.

EXAMINATION.—On arrival at hospital the patient showed the following clinical condition. He was wearing an anxious expression, but trying to hide it. Pulse 72, temperature 99.2°. Tongue dry and coated with a thick brownish fur. Arteriosclerosis present but no organic disease discernible in the heart, lungs, or kidneys, urine normal. Rectal examination revealed a rectum full of feces. The bowels had not been moved for two days. Examination of the abdomen showed well-marked small-intestine peristalsis, but no rigidity or tenderness was noted.

TREATMENT.—An oil and turpentine enema was given which emptied the lower bowel but no flatus was passed. A dose of morphine, gr. $\frac{1}{4}$, was injected and a large poultice applied to the abdomen. At the end of four hours there was no alteration either way, so he was given a good dose of castor oil. This increased the peristalsis and caused some pain, but no flatus was passed.

DIAGNOSIS — Acute intestinal obstruction of which the cause could not be ascertained

OPERATION — Eight hours after admission the abdomen was opened in the mid-line, and as no particularly distended or collapsed gut was seen, the large bowel was first traced from cæcum to rectum without any obstruction being found. Then the small bowel was followed backwards from the ileo-cæcal valve and about ten feet from the valve a foot of bowel was noticed to be anæmic, and reacted sluggishly to stimulation. As there was nothing at the time to account for this it was passed over. No distention of the gut above this area, and no collapse below it, were noted. About four feet from the duodeno-jejunal junction the sacculated condition of the bowel shown in *Fig 260* was encountered, and traced to the duodenojejunal junction, where the most marked sacculatation was discovered. As there was no sign of inflammation in any of the sacculi and all were empty, nothing further was done and the abdomen was closed.

AFTER - PROGRESS — On Feb 16, the bowels were well moved by means of an ordinary enema, with the passage of flatus, and the patient appeared comfortable. Liquid paraffin was given night and morning. On Feb 18 his temperature commenced to rise the abdomen showed increasing distention, and was ridged with marked small-intestine peristalsis. Oil and turpentine enemata had no effect. The tongue was dry. Signs of pneumonia were evident at the right base. Death occurred on Feb 19.

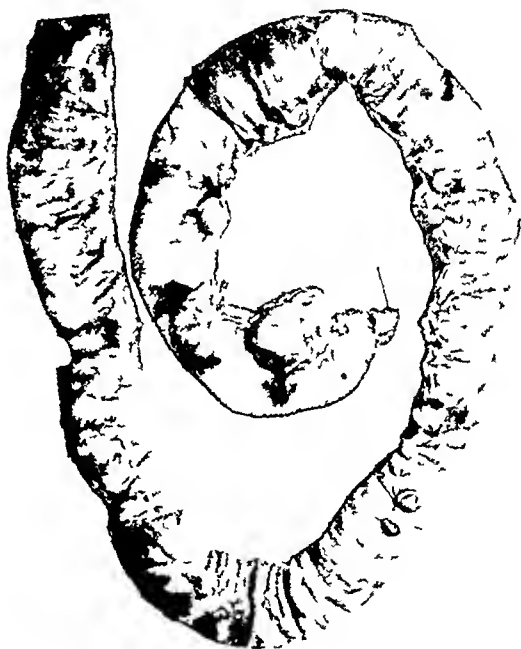


FIG 260 — Sacculitis of jejunum

POST - MORTEM — On opening the abdomen the piece of bowel which had been observed during the operation to be anæmic and sluggish to stimulation was found lying gangrenous. A small embolus of the mesenteric artery supplying the segment was found. The bowel above the gangrenous loop was now markedly distended. The middle cusp of the aortic valve showed a definite hard excrescence about the size of a split pea with roughened edges. Aortitis was present in a fairly well-marked degree. There was pneumonia of the right lower lobe in a badly adherent lung. The left kidney showed a large cyst (size of Tangerine orange) at the lower pole and studded throughout the substance were numerous small infarcts. The right kidney appeared more healthy with fewer infarcts. The liver was friable but showed no macroscopic pathology.

The section of the small bowel in which the sacculi were present was

removed blown up and sent in a sealed tin to Professor Saint, of Cape Town University, for a pathological report and preservation of the specimen

Report—The specimen (*Fig 260*) consists of the upper jejunum immediately below the duodenojejunal flexure, 100 cm long. All along the mesenteric border of the gut are seen sacculi of varying size. The largest is about 6 cm in diameter, the average about 1.5 cm and the smallest just visible. The largest are situated in the upper portion of the gut. All the sacculi are situated in the region of the mesenteric attachment, and a large number are alongside vessels which are running into the bowel wall. Those which do not bulge into the mesentery appear to be at points where vessels are perforating the wall. The mouths of the sacculi are very wide. There is no sign of inflammation in any of them, and no concretions are present in them.

Microscopic Report of Small Sacculus (Professor BAUMILLER, Cape Town University)—The mucosa bulges through a wide breach in the muscle coats, apparently at the point where large arteries and veins pierce them. The walls of the sacculi are thus composed of mucosa, submucosa and serosa.

COMMENTARY, BY PROFESSOR SAINT

The Acute Intestinal Obstruction—Embolism of the mesenteric vessels is not common, but one cannot regard it as rare and cases of this type are encountered from time to time. Usually the obstruction is not complete, and flatus continues to be passed. Blood-stained diarrhoea, too, is not infrequent.

In the present case with complete obstruction no physical signs of endocarditis were observed either before or after operation and no diagnosis of the cause of the obstruction was made. The anæmic condition of the affected loop of gut and its diminished contractility were commented on at the time of operation, but its condition was not outstanding enough to command a detailed examination, and it was not credited with being the cause of the obstruction. This was accounted for by the absence of any marked difference in the bowel above and below the loop which is somewhat surprising in view of the exaggerated degree of visible peristalsis present before operation. Otherwise no doubt the absence of pulsation in the vessels supplying the loop would have been noted and the cause thereby diagnosed.

The exaggerated visible peristalsis is worthy of mention as some surgeons emphatically deny its occurrence in acute intestinal obstruction. If carefully looked for, it will usually be seen, though not in so marked a degree as in the case described above.

The Sacculated Condition of the Jejunum—This condition is always interesting, and is especially so in the present case. One is usually accustomed to associate with the development of sacculi in any of the hollow muscular systems—(1) obstruction with a resultant increase in the intravisceral tension and (2) a weak spot in the wall. The weak places in the wall may be either congenital or acquired, the congenital being usually at situations where some structure pierces the wall—e.g., blood-vessels, or the ureter in the urinary bladder—while the acquired are usually the result of some destruction of the outer walls either by injury or inflammation. Where the weak spot is congenital, and is due, as it mostly is, to the perforation of the wall by a

blood-vessel, the commonest type of sacculus is found, and consists of a protrusion of the inner coat through the outer coats, so that the muscular coat particularly is not represented in its wall. This is the usual sacculus of the mucus-lined hollow muscular systems. Where the weak spot is acquired and is due to destruction of the outer coats by injury or inflammation, the inner lining bulges outwards, and the muscular coat may at first be represented in the wall, deficient it is true but still there, though later it is entirely absent. This is more particularly seen in the vascular system in aneurysm of the big vessels. In the vascular system no obstruction or increased tension is necessary, if the weak spot be present, as the normal blood-pressure is sufficient to produce bulging.

"Sacculi are never of congenital origin and have consequently not been (*rarely been*)^{*} found in youth, they are associated with obstruction of the outlet, and weakness of the wall, of the affected viscus, they are multiple, they are thin-walled, because they are mostly hernias of the inner (mucous or endothelial) coat through the muscular coat, they are rounded in shape, they do not (usually) attain to very large size, and they are practically limited to advanced life. In the urinary bladder, all parts of the gastrointestinal tract, the gall-bladder, the vermiform appendix, and Fallopian tubes similar swellings have been described, indeed it is safe to say that they will be found, if sought for, in any of the hollow muscular-coated viscera" (Rutherford Mouison).

Common to all sacculi, in view of their mode of origin, are (1) *Reducibility* of the contents into the parent cavity, and (2) *An expansile impulse* in the sacculus on increase of pressure in the parent cavity. Where these can be elicited, they constitute pathognomonic signs of the condition. They are of chief importance in the case of aneurysms. Other sacculi are usually too deeply situated to be examined except where exposed by surgical operation.

Rutherford Mouison has further emphasized the liability of sacculi to the same pathological processes as occur in the appendix and other diverticula. All of them may harbour concretions, and all of them are liable to infection by micro-organisms and attacks of inflammation, while the terminations of the inflammation differ in no way from what is found in the appendix.

From the clinical data of the case reported above, it is obvious that there was no evidence of any obstruction having been present previous to the acute one under consideration, which was of a few days' duration only. One must therefore conclude that the ordinary intravisceral tension had been sufficient to produce the bulgings. Under these circumstances one is inclined to accept the probability that the intestinal wall was defective, in so far as the normal weak spots in it, where the vessels perforate the muscular coat, were larger than normal. This is borne out by dissection of the gut. The sacculi, as described, were of the common type, and occupied the favourite portion of the small bowel when they occur in it, viz, the proximal part of the jejunum.

* The italics are mine.

In comparison with this case one might quote that of a lady in whom one was asked to undo a gastro-enterostomy performed four years previously for a duodenal ulcer. The patient was relieved for two years, and then began to have a great deal of pain after food etc., suggesting the possibility of a gastrojejunal ulcer. At operation, the jejunum was found to be twisted on itself at the anastomosis giving rise to considerable obstruction in the small proximal loop. In this dilated and hypertrophied loop a single sacculus, the size of a pea, was present. No detail of its exact relations could be noted except that it was slightly to the side of the mesenteric attachment. It was infolded by Lembert sutures. In this situation a sacculus of such a type is by no means common.

Before leaving the subject one feels one ought to register a word of censure against the use of the term *diverticulum* to describe these bulgings. It is one example of what appears to be an inherent weakness of the profession, apparently hereditary, to use either the same word to describe quite different pathological conditions or different words to describe the same pathological condition. As opposed to *sacculi diverticula* are of congenital origin, all the coats of the affected viscus or hollow muscular system enter into the composition of their wall, all have a special vascular supply of their own, they are seldom, if ever multiple, and they are found at any age. The use of the term *sacculus* to describe these acquired bulgings through the walls of the hollow muscular systems, which ought to include aneurysms is simpler and clearer than the ungainly terms 'false' or 'acquired' *diverticula*, this is more especially the case when inflammation has arisen, for in such an event the term '*diverticulitis*' is used alone and one is left to guess whether the congenital or acquired bulgings are being discussed.

RARE LESION OF UPPER END OF FEMUR. FRACTURE OF HEAD OR SEPARATION OF EPIPHYSIS

BY JOSEPH J LEVIN, JOHANNESBURG

FRACTURE of the head of the femur or separation of the upper epiphysis is of sufficient rarity, I think, to justify publication of the following case. The history, for which I am indebted to Dr H Q F Thompson, who treated the case during life, is as follows —

"Namadi Nyambaan, a native, 33 years old, employed underground in a mine, was admitted to hospital on Jan 2, 1923, for an injury to the right hip caused the previous day by a blow from a truck (? cocopan). He stated that he did not fall down nor was he jammed against anything. He continued to work. That same night his right leg was painful, and he reported to the dressing station next day. On admission, the patient walked with a limp. Examination revealed no abnormality about the right femur or hip-joint. There was no swelling or shortening, but there was definite tenderness on pressure over the ilium. There was no wound or abrasion. It was thought

that he probably had a contusion of the ilium. He was kept in bed, and a lead and opium dressing was placed over the right buttock.

"PROGRESS—Jan 7 Patient got out of bed and walked about, though still with a limp. This limp, instead of improving with exercise, became more pronounced and on Jan 21 patient remained in bed. On Jan 28 he was X-rayed, but no abnormality detected. Patient did not get up and complained of pain in his right buttock. He always placed his finger on one point where he said the pain was worst. This point corresponded with the hip-joint. There was no swelling to be seen. Patient then began gradually to flex his legs and would lie in bed with his knees under his chin. He never lay on his back, but preferred the right side.

"Feb 17 His temperature rose to 101.6° and the next day an exploratory needle was inserted through the right buttock down to the hip-joint and in several directions, but no pus was found. (*Patient's mouth and gums were in a very bad condition*).

"Two days later he was unable to extend the right

lower limb, either at the hip-joint or at the knee, and it was found impossible to rotate or move the thigh in any direction. A certain fullness about the right groin was noticed and on Feb 21 an examination under an anæsthetic was performed. An exploratory needle was again used, but no pus was found. The limb moved freely in all directions, and no abnormality of any sort was noticed. An incision was made in the right buttock and the finger inserted down to the hip-joint. Nothing abnormal was felt there, but I imagined that there was a roughening of the ilium above the ridge of the acetabulum. A drain was inserted into the wound though no pus had been found. The right lower limb was fixed on a back splint from about

the middle of the thigh down—an ordinary back splint with a foot-piece.

"Feb 22 The right lower limb was put on extension by means of strapping and weights, from about the middle of the thigh. During the next three days the temperature was high, and the wound clean. No complaint of pain was made, but on Feb 26 pus began to appear from the wound and drained freely.

"March 5 Patient dislocated his jaw, this was reduced under a general anæsthetic. Patient died at 9.40 a.m. the day following."

The points in the history to which I would draw special attention are

(1) That when the patient 'walked about' on Jan 7, the limp became more

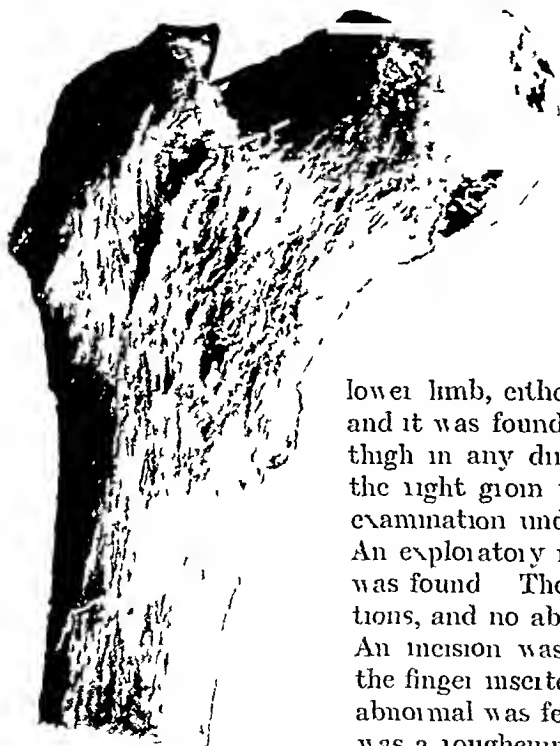


FIG. 261.—Fracture of head of femur

pronounced, (2) That the patient's mouth and gums were in a 'bad condition', (3) That an exploratory needle was used on two occasions, and that an incision was made over the buttock, (4) That an X-ray photograph was taken, but revealed no fracture

On March 7 I made a post-mortem examination, and found a septic incised wound in the right buttock. On investigating the hip-joint, I found the head of the bone in the acetabulum separated from the neck and shaft—in fact, what I considered an unminuted fracture of the head of the femur, the line of fracture being clearly indicated in the photograph of the specimen shown in *Fig 261*. The joint was very septic and contained green stinking pus. The buttock was very septic. I gave as the cause of death Fracture of the femur (head)—unminuted. Sepsis in hip-joint and buttock. Septic absorption.

The points for discussion seem to me to be (1) Was this a fracture of the head of the femur, or was it a separation of the epiphysis? (2) Did the fracture or the separation occur on the first of January, or was the lesion due to scurvy alone? (3) Was it the end-result of local sepsis, sepsis in the mouth, or scurvy, superadded to a minor injury in the region of the hip-joint?

1 If this were a separated epiphysis one would have expected it to have followed the normal line of the junction of the epiphysis with the diaphysis, but examination of the specimen shows that this separation of head from neck is at a higher level than the epiphyseal line although posteriorly it does for a short distance coincide with it. Further, the age of the patient—33—is against a separation of the epiphysis. The head of the femur fuses with the shaft between the ages of 18 and 20. I am therefore of opinion that this was not a separated epiphysis but a fracture. In this the pathologists at the South African Institute for Medical Research agree with me.

2 The question as to whether this fracture occurred on Jan 1 as a complete fracture is very difficult to decide. If so, then it is difficult to understand how the boy was able to walk. It seems possible that the boy received an injury on that date which partially fractured the head of the bone and did little or no damage to the capsule of the joint. One can conceive of such an injury being painful yet not preventing the patient from moving about—though with difficulty. Subsequently on Jan 7 the boy got out of bed and walked about till Jan 24, and the notes say that the limp became more pronounced, probably, owing to the effort of getting up and walking about. From Jan 7 to Jan 24, the bone may have been completely fractured. Against this opinion is the fact that the patient was X-rayed on Jan 28 but no abnormality was detected. Radiologists, however, are not always successful in their photographic efforts, and this X-ray photograph—which I have seen—is admittedly not a good one—and although even in the best of light one cannot see any fracture, yet it seems to be possible that there may have been one.

In view, however, of the fact that the notes state that the patient's mouth and gums were in a very bad condition (Dr Thompson informs me that they showed evidence of scurvy), for which reason the boy was put on to an anti-scorbutic diet, the question arises as to whether this was not a spontaneous fracture, subsequent to Jan 28, due to scurvy alone. Hess¹ favours this

possibility, it would be impertinence therefore on my part to doubt that such lesions could occur. But while scurvy is very common on the reef amongst the mine boys, yet one has not heard before of such a lesion occurring amongst them and therefore one is inclined to question this being a fracture due to scurvy. Examination of the specimen affords no help, owing to the presence of advanced sepsis.

3 I am informed by Dr Oienstem Superintendent of Sanitation, Rand Mines Ltd, that it is rare to find spongy and swollen gums amongst the mine natives due to scurvy uncomplicated by pyorrhœa, the two seem nearly always to be indistinguishably combined, and therefore one is bound to consider the remote influence of the condition of the boy's mouth in its relation to the original injury which leads us to the third alternative namely, that the boy received a minor injury on Jan 1, and owing to the septic and scorbutic condition of his mouth he developed an arthritis of the hip-joint, which became septic. That this is possible there is no denying, and it is confirmed by Douglas Knockel.²

There is also the possibility—and I say this with diffidence—that sepsis may have developed in the joint owing to the two explorations with a needle, or the incision which was made over the buttock.

Fracture of the head of the femur (or, for that matter, separation of the epiphysis) is notoriously a very rare occurrence.

I nevertheless diffidently express the opinion that this boy—as the result of the injury on Jan 1—fractured the head of his femur, and that subsequently, owing to the septic and scorbutic condition of his mouth, or to sepsis accidentally introduced locally, he developed a septic arthritis of his hip-joint, which prevented the fracture from uniting, and which ultimately caused his death.

REFERENCES

¹ HESS, *Scurvy Past and Present*

² KNOCKER DOUGLAS, *Accidents in their Medico Legal Aspect*, 1910, 501

REVIEWS AND NOTICES OF BOOKS

A System of Surgery Edited by C. C. CHOYCE, F.R.C.S. Director of the Surgical Unit University College London, and J. MARTIN BLAIR, M.D., Professor of Bacteriology University of Liverpool. In three volumes. Second edition. Vol. I pp. 1013, with 19 coloured plates, 58 half-tone plates, and 215 figures in the text. Vol. II, pp. 1057, with 20 coloured plates, 10 half-tone plates, and 226 figures in the text. Vol. III pp. 1176, with 11 coloured plates, 30 half-tone plates, and 329 figures in the text. London: Cissell & Co. Ltd. 46

THE second edition of this important work was in course of preparation in 1914, but its appearance had to be postponed until after the war. This delay, however, has been more than compensated for by the care spent on the present edition and the well-balanced attention given to the various subjects treated. Not only have all the articles been revised, re-written, and brought up to date, but in some sections new authors have contributed to the work. These are Mr Magnus Redding on X-ray diagnosis, Mr Hey Groves on fractures, Colonel Harrison on syphilis, Colonel West on tetanus, Mr Norman Patterson on the diseases of the throat, and Mr Trethowan on orthopaedic surgery. There are upwards of 150 new illustrations, including 50 new plates.

Volume I deals with surgical bacteriology (Dreyer) and its therapeutic applications (Eyre), inflammation (Beattie and Maynard Smith), suppuration (Lenthall Chertle), ulceration (Pinnett), gangrene (Nitch), wounds (Choyce), burns and scalds (Woodward), constitutional results of trauma (Russell Howard), toxæmia, septicæmia, and pyæmia (Martin), tumours (Raymond Johnson), examination of the blood and cerebrospinal fluid (Beattie), X-ray diagnosis (Magnus Redding), general anaesthesia (Blomfield), local anaesthesia (Gwynne Williams), spinal anaesthesia (McGavin), tuberculosis (Beattie), syphilis (Harrison), venereal diseases other than syphilis (Leedham-Green), certain tropical diseases (Daniels and Low), glanders (Rock Carling), actinomycosis (Choyce), tetanus (West), hydrophobia (Calmette), anthrax (Turner), diseases caused by animal parasites (Madden).

All of these articles are well illustrated, practical, and up to date. Those which specially attract attention are the chapters on practical bacteriology and blood examination by Beattie, on gangrene by Nitch, who gives a good account of modern methods of treatment, e.g., division of the sympathetic, on tumours by Raymond Johnson, who has selected a remarkably good series of illustrations, on X-ray diagnosis by Magnus Redding, and the chapter on syphilis by Harrison.

Volume II contains the following articles. The breast (Simpson Handley), the spleen (Gordon-Watson), face, lips and palate (Nitch), tongue (Clayton-Greene), salivary glands (Ivor Back), œsophagus (Rigby), stomach and duodenum (Sherren), intestines (Alex. Miles), appendix and peritoneum (Sargent), hernia (McGavin), rectum (Clogg), liver, gall-bladder, and pancreas (Grey Turner), urinary organs (Thomson-Walker), male genital organs (Russell Howard).

Handley's chapters on the breast give a thorough account of his work on permeation, including his recent views about Paget's disease of the nipple. There is also a detailed description of the operative and post-operative treatment which is of great practical value. Prophylactic X-ray treatment is to be applied to every case after operation. Radium tubes are buried for twenty-four hours in the intercostal spaces and in the supraclavicular fossa. Open-air treatment for some months is strongly urged.

Nitch's article on cleft palate is a model of clear description and illustration. He holds the balance almost evenly between the early flap operation and the later operation by direct suture but he definitely states that the second month of life is the time of choice.

Clayton-Greene, writing on cancer of the tongue, expresses the generally accepted pessimism about methods of treatment and results. In regard to cutting operations, he urges the necessity of removing the tongue muscles down to the hyoid bone. The method of primary removal of glands from the neck, followed by diathermy to the tongue, is that recommended.

Sherren's article on the stomach and duodenum is marked by his clear exposition and discussion, especially in relation to the diagnosis and treatment of gastric ulcer and cancer. He holds that for a 'free' gastric ulcer, gastro-enterostomy is an efficient treatment, and he would reserve partial gastrectomy for cases of adherent or indurated ulcers.

Other notable articles in this volume are those by Miles on the intestines, Grey Turner on the gall-bladder and pancreas, and Thomson-Walker on the urinary organs. Space forbids these being described in any detail.

Volume III contains the following articles: Female genital organs (Bonney), cardiovascular system (Roek Carling), lymphatics (Dobson), neck (Edmunds), nose (Barwell), throat and ear (Patterson), œsophagoscopy and bronchoscopy (St. Clair Thomson), lungs and pleura (Morrison Davies), nerves (Sherren), skull and brain, spine and spinal cord (Trotter), jaws (Fitzwilliams), skin (Legg), muscles (Roek Carling), bursæ (Telford), diseases of bones and joints (Choyce), fractures (Hey Groves), orthopædic surgery (Trethowan). This volume is largely concerned with 'special departments' of surgery, and must have caused the editors much care and anxiety in making as much as is necessary for a work of this kind, without making it too long.

Trotter's articles on the brain and spinal cord are remarkably interesting and suggestive, because they deal so well with general principles without being overburdened with detail.

Choyce, too, in taking the large subject of bones and joints, writes very clearly and dogmatically as a teacher speaking to students, and he has included all the essentials of these subjects in a comparatively small space. This has been rendered easier for him by the fact that special sections on fractures and on deformities cover much of the ground of bone and joint surgery.

Hey Groves, in writing of fractures, deals chiefly with the principles underlying various methods of treatment, e.g., those by fixed splinting, early mobilization, traction, open operation, and bone-grafting.

Trethowan writes on the surgery of deformities, and his article is fresh without being heterodox. It is evident that he has had difficulty in keeping to his allotted space, as so much of his article has been relegated to small print.

The work as a whole as well as in detail, is a good representation of present-day British surgery, and as such it stands to day without a rival. The publishers, as well as the editors, are to be congratulated on the way in which the book is arranged, printed, and illustrated. The coloured plates are numerous and beautiful, whilst the half-tone plates and other illustrations are clear and well chosen.

Die Willkürlich bewegbare künstliche Hand. By PROFESSORS F. SAUERBRUCH and C. TEN HORN, Universitätsklinik, Munich. Vol. II. Royal 8vo. Pp. 249 + iv, with 230 illustrations, part in colour. 1923. Berlin. Julius Springer. Unbound, 11s. 8d. Bound, 12s. 11d.

THE proposals of the Italian Vanghetti to utilize the muscles of a stump for the movements of the fingers of an artificial hand were by no one taken up with such zeal and energy as by the German surgeon Sauerbruch. But while Vanghetti devised many methods of achieving his end, Sauerbruch confined himself to one alone, namely the tunnel or cannulization method. The technique which he employed

was an adaptation to local circumstances of Rochet's operation of metachronism. This procedure and its results were the subjects in 1916 of *Die künstliche bewegbare Kunstliche Hand* in which Sauerbruch recommended his operation. Of this book the work now under notice forms the second volume. In the interval cinematization has been tried in most of the lately belligerent countries, but the results have been generally disappointing no matter whether Sauerbruch's or other procedures have been employed and we believe that we can safely assert that it has been practically abandoned much to the disappointment of those surgeons who had enthusiastically welcomed the innovation. It was found in this country that there were two great obstacles in the way of success. One of these was the lack of sufficient power in the muscular motors, and the other was the difficulty of fitting a satisfactory prosthesis despite many experiments which were made on behalf of the Ministry of Pensions.

Professor Sauerbruch now describes the latest improvements in the technique of the operation and emphatically reasserts his claims that it is a practical success when it is performed in suitable cases with due consideration of all details and when such prostheses as he describes are used.

It seems to us clear that on the evidence brought forward there are a certain number of cases in which success has been attained but only after long and careful training and with very accurately adjusted appliances and that other surgeons in Germany have not formed nearly such favourable opinions of the procedure as those that are held by Sauerbruch and his school. It is, we think, to be regretted that the comparative isolation of Germany in general and of Bavaria in particular has prevented the surgical world from testing for itself the actual worth of the method by investigation on the spot, and we hope that it will not be long before such an inquiry is made. In the meantime, if any British surgeon is tempted to cinematize an amputation-stump by the tunnel method, he could not have a better guide than this volume, in which every detail is discussed and profusely illustrated, both as regards the amputation-stump and the various types of prosthesis suitable for it.

Orthopædic Surgery By SIR ROBERT JONES, K.B.L., C.B., Director of Orthopædic Surgery, St. Thomas's Hospital, Lecturer on Orthopædic Surgery, Liverpool University and ROBERT LLOYD, M.D., F.A.C.S., John B. and Buckmaster Brown Professor of Orthopædic Surgery in Harvard University. Pp. 699, with 712 engravings. 1923. London: Oxford Medical Publications, Henry Frowde and Hodder & Stoughton. 42s. net.

The reputation of both the authors of this book is so great that a joint work from their pens is assured of a warm welcome from general surgeons as well as from those who have specialized in orthopædies. In the preface the authors explain their dissatisfaction with the title of their work—a title adopted for want of a better—because they believe that the principles governing the diagnosis and treatment of these conditions should be those and only those embodied in general surgery.

The general arrangement of a book on orthopædic surgery is always a matter of difficulty. We think the authors have been wise in beginning with the anatomy, physiology and general pathology of joints and then passing on to the traumatic affections of joints. A description of the anatomy of the individual joints precedes each section and will be found useful to the student. These chapters embody the authors' views, which are for the most part well known from their previous writings, but are enriched by numerous little hints which their enormous experience enables them to give. We must however confess to disappointment with the section on coxa vara, it leaves us with no clear idea as to their views on the nature and treatment of that well-defined class called infantile or cervical coxa vara.

On the vexed question as to the existence of an affection worthy of the title of 'osteochondritis desiccans' the authors are definitely on the side of those who

believe trauma to be responsible in the great majority of cases. The chapter on "Stiffness of the joints—Adhesions and Ankylosis" is full of sound instruction. Tuberculosis of the joints and spine is very fully dealt with in five excellent chapters. Every question is discussed with the minutest care, the reasons for every detail of treatment being carefully explained.

In these chapters, as elsewhere throughout the book, whenever the authors are not in entire agreement on a particular point, each has stated his own opinion and added his initials. Similarly when the general practice in dealing with a particular affection in America differs from that favoured by surgeons in this country, both methods of treatment are given.

One or two points in these chapters call for comment. For instance surprise will we think, be caused by the advice that when a cold abscess threatens to burst, a small incision, half an inch in length, should be made in it, and a drain inserted for not longer than twenty-four hours, the dressings being changed as infrequently as possible. It is true that the authors insist on the necessity for the most scrupulous care in the subsequent dressing of the wound, and say, "the surgeon who cannot provide this should let abscesses alone."

We must confess regret at the inclusion of an illustration and description of a *single* Thomas hip splint. Certainly it is stated that it is used, by one of the authors, only when disease in the hip-joint is quiescent and ambulatory treatment has begun, but it is a splint with which it is difficult or impossible to prevent deformity, particularly in the form in which the splint is usually and incorrectly made, moreover, it is one which is regarded by some—wrongly we think—as an efficient means of treating arthritis. In the section on tuberculosis of the shoulder-joint illustrations are given of treatment in plaster-of-Paris with the arm abducted and apparently externally rotated to the full extent at the shoulder. This surely is a mistake, as the positions illustrated do not agree with those described in the text as being the best, and generally accepted as such, when ankylosis of the joint is expected or feared. Excision of the ankle by the transverse incision to which Ochsner's name is attached in the book does not seem to differ materially from the method of Huter, though even the latter was not by any means the first surgeon to practise it.

Most of the other diseases of bones and joints are fully dealt with in a series of chapters. A section is given to muscle and bone atrophy and another, particularly clear and instructive, deals with functional contractions and deformities. Spastic paralysis has a chapter to itself—one of the best in the book. The various methods of treatment of this affection are dealt with in a particularly clear manner. The authors leave the reader in no doubt as to their preference for the older methods of attacking the spastic muscles directly by tenotomy and excision of muscle, though detailed descriptions of the Stöffel and other methods are given.

Polymyelitis is, of course, dealt with exhaustively. The avoidance of over-fatigue of muscles recovering from paralysis is rightly insisted upon as of prime importance. The operative measures available when further recovery is not expected are dealt with in a clear manner, the pages being plentifully supplied with useful illustrations. The remaining chapters deal with obstetric paralysis, congenital deformities, torticollis, club-foot, etc.

In the discussion of obstetric paralysis there is no definite statement that posterior displacement of the head of the humerus is a common late result of this affection, yet the existence of such is admitted in the reference to operations designed by other surgeons for its relief. In so called congenital torticollis the authors—we think rightly—favour division of the sternomastoid and surrounding fascia by the open method, and condemn subcutaneous tenotomy. The last chapter is devoted to scoliosis, the subject, of course, of the excellent monograph first published some years ago by one of the authors.

Practically every affection which one might expect to find is included in the book, Dupuytren's contraction is, however, a noticeable exception. The book contains such a wealth of information and sound advice, as was only to be expected, that the reader's attention is rather caught by certain imperfections, one or two

of which have been referred to. No doubt improvements will be made here and there in the next edition which will certainly be called for before very long. We noticed rather an unusual number of printer's errors. The illustrations are numerous and in every way worthy of the book which will certainly be read by a very large number of surgeons and students.

Die ersten 25 Jahre der Deutschen Gesellschaft für Chirurgie, ein Beitrag zur Geschichte der Chirurgie. By FRIEDRICH TRENDLENBURG. Demis 8vo. Pp. 467. 1923. Berlin. Julius Springer. 10s.

UNDER the title "The First Twenty-five years of the German Society of Surgery" Professor Trendelenburg, one of four surviving original members, has classified in more than sixty chapters the proceedings of the society between the years 1872 and 1899. As the second part of the title indicates he has made it a contribution to the history of surgery, particularly, he it remarked, from a German point of view. From the book may be learnt how it came about that where is at the London Congress in 1881 the leadership seemed to be with British surgery, at the Berlin Congress in 1890 German surgery had taken the lead over all countries.

Lister's procedure inspired by Pasteur had reached its acme of fame at the London Congress. It had rendered possible the successful treatment of conditions for which operations when undertaken at all, had formerly been risky ventures. Moreover, successful experiments on animals could be likewise carried out under antiseptics and anaesthesia, which thus directed the way to new operations. An opponent of Listerism had used the jangle of words, the ritualism of Listerism, by so doing he directed attention to Lister's eternal merit—that of bringing into surgery a ritual in place of slapdash improvisations. In future the medical student and nurse probationer learnt that surgery demanded a procedure methodical in detail. An exponent of Listerism seemed to consider Lister's particular procedures as the ritual, as if it were a fixed and permanent dogma. By it Spencer Wells had reduced the mortality following ovariectomy, but for abdominal surgery in general part of Lister's method was unsuitable and to this English ovariectomists offered only negative criticism. Koch and his pupils cultivated bacteria on solid media, identified them by staining, and proved the efficiency of steam under pressure to destroy them. With all German persistence and diligence such men as Neuber, of Kiel, and Schimmelbusch, assistant to Bergmann, in Berlin, sought out the infective agents of wounds, whether on the skin of the patient or on the surgeon's hands and instruments, and new ways of sterilizing sources of infection without doing harm. At the same time the air was demonstrated not to be such an important source of infection. From the demonstration given by Schimmelbusch at the Berlin Congress in 1890 dates the gradual supersession of the so-called 'antiseptic' by the 'aseptic' method.

Before 1872 German surgeons had had only one possible opportunity of meeting—namely, at the Surgical Section of the Naturforscher's Versammlung held at various places. By the see-saw of history the Germans were once again the conquerors, they had united themselves into the Reich with Berlin as the capital, they had received a large indemnity in cash, also territory in the Rhineland—which was to undergo transformation from the condition described in *Childe Harold*—and money was forthcoming for the rebuilding of hospitals and the establishment of institutions for research.

The principal founders of the society were Bernhard Langenbeck, nephew of Konrad Langenbeck of Göttingen, and known for his cleft-palate and pharynx operations. Gustav Simon, of Heidelberg, the experimenter and operator on the spleen and kidney, Richard Volkmann, of Halle, who extended the English observations on chimney-sweep's cancer to tar cancer, and described the ischæmic contracture of the forearm. Victor Bruns, of Tübingen, the first to remove a polypus from the larynx in the case of his brother, Gurli, the author of the unique history of surgery before the study of human anatomy, Esmaich of Kiel, the advocate

of first-aid in both war and peace. The first treasurer was Professor Triendlenburg then assistant to Langenbeek, he had previously in 1869 invented his tamponade cannula, and later, in 1881, first employed his raised pelvis position when operating for a vesicovaginal fistula across the bladder, next when removing polypi from the bladder.

It was some years before a regular place of meeting could be founded, when in conjunction with the Berlin Medical Society, Langenbeek-Vnelow House and Library arose. A few non-German surgeons attended. William MacCormac was an original foreign member, the one survivor, Sir Alexander Ogston contributed in 1877 an account of his operation for genu valgum, and in 1880 described the staphylococci invariably present in acute abscesses, at the first meeting Jonathan Hutchinson described his successful operation for intussusception, Paget and Spencer Wells were made honorary members in 1885, Victor Horsley made contributions on thyroid and brain surgery, and Arthur Barker was often present. The only Frenchman to attend, Doyen, in 1895 and 1898, concerned himself with his cinema demonstrations, and attacked his fellow-countryman, Fran, about the piecemeal removal of the uterus. Among Americans, Senn, Murphy, and Roswell Park were present at meetings. There was a laughable hitch in Senn's demonstration of his method for locating intestinal obstruction when it was found that the hydrogen was being passed into the wrong orifice. The following may be selected as great advances made in Germany during the period under review.

After renewed experiments on animals, using antiseptics and anaesthesia, by Wofflei, Czerny, Winwarter, and others, Billroth of Vienna, commenced his operations for cancer of the stomach, Winwarter that of anterior gastrojejunostomy, Hacker the posterior operation, and Mickulicz, of Breslau, the practice of operating at once for a perforation.

General anaesthesia never attained marked success because of the lack of special anaesthetists who could instruct medical students. Instead Schleich, Braun and Bier directed attention to local, regional, and spinal anaesthesia, Röntgen of Würzburg, adapted advances made in physics to practical surgery, and Kummell, of Hamburg, demonstrated the use of the discovery for the diagnosis of injuries to the skeleton.

Fehleisen in 1882, starting to inquire into the influence which an attack of erysipelas appeared to exert sometimes upon the course of lupus and sarcoma, identified the streptococcus, and this original idea was followed up by Dr Coley from 1895 onwards.

The grave operation of excision of the larynx was taken up by Billroth in 1874 and Gluck proposed the preliminary division of the trachea, but the results were unfavourable. Rose, under the title 'broncheotomie', later known as 'thyrotomy' or 'laryngo fissure', proposed the more limited operation which Hahn in Berlin and Butlin and Scmon in this country rendered a success. However, when the case of the Emperor Frederick arose, it was the larger dangerous operation which was proposed and rejected.

To make the author's 'Beitrag' into a real history of the period would require an extended account of the work of surgeons in other countries.

Chirurgie des Voies Biliaires. By HENRI HARTMANN and Associates. Fifth edition. Imperial 8vo. Pp 356, with 89 illustrations. 1923. Paris. Masson et Cie. 30 fr.

This is the fifth edition of the book. The last was produced before the great war. Hartmann leads off with a chapter giving the relative frequency of all kinds of operations performed at Hôpital Bichat in a series of 3062, and the cause of death in each of the 166 fatal cases in the series. The next chapter, by Maurice Vnenque, deals with some rather unusual and abstruse points in the naked-eye anatomy of the gall-bladder and the effects of various curvatures of the gall-bladder which he describes on the pathology of the organ. Some account is given of the normal

and abnormal vascular supply but we think that the importance of this from the surgical point of view is not sufficiently recognized—there is nothing said about the anatomy of the bile ducts, and the frequent variations in these structures are not mentioned, though their importance to the surgeon cannot be too strongly emphasized. The author of this section devotes some space to a description of the ligaments of the gall-bladder—he considers the cysticoduodenal of embryological origin, whereas the cysticocolic is only found as a result of pericholecystitis.

The greater part of the book is taken up with the consideration of the various types of cholecystitis. Inflammation of the gall-bladder is regarded as *the* important disease, gall stones being merely an incident in the biology of this lesion. We think that most surgeons are in agreement on this point. Hartmann is responsible for Chapters III and IV, in which the pathogenesis and clinical aspects of cholecystitis and gall-stones are discussed. Though the subject is very clearly and fully set out, the conclusions do not differ materially from those held by most authors of note—namely, that the gall-bladder is primarily infected from the blood, and that infection of the tracts with *B. coli* is a secondary affair, the cholecystitis having opened the way by causing stasis of bile. The whole of this article is excellently illustrated by the recital of cases to bring out the essential points under discussion. However there is nothing new.

Chapter V, by Maurice Renard, is concerned with the biological and pathological study of cholecystitis, which according to him is always an acute infection in the first place, the sequelæ appearing when infection continues in an attenuated form. A series of thirty-four plates illustrates better than any description the sequence of events from the acute infection to the final stages of sclerosis of the gall-bladder and surrounding tissues with involvement of adjacent organs. These plates provide one of the best features of the book.

In Chapter VI, Hautefort reviews the results of experimental ablation of the gall-bladder. He claims to have shown that any stump of the cystic duct which may be left between the ligature and the common duct after cholecystectomy will dilate and form a new, though small, gall-bladder in which bile will accumulate, also that all the extra-hepatic ducts share in this dilatation, and only the extra-hepatic ducts. These experiments, it should be remembered, were performed on animals and do not necessarily apply to the human being. We do not remember ever having seen a dilatation of the stump of the cystic duct whilst doing secondary operations on the bile-ducts, though it is not at all uncommon for a varying length of the cystic duct to be left after cholecystectomy. Moreover, American experimenters seem to have satisfied themselves that though at first there is some holding up of the bile in the extra-hepatic ducts, very soon the pressure causes the sphincter of Oddi to yield and thereafter bile escapes continuously. Indeed, this permanent relaxation of the sphincter is one of the reasons advanced for performing cholecystectomy in cases of chronic pancreatitis, the cause of bile regurgitating into the pancreatic duct being thereby removed.

In Chapter VII, Hartmann deals with the technique of operations on the bile ducts. During the operations he stands on the left of the patient, as he thinks he is able to get an easier and a better view of the whole operative field. He describes his method of conducting all the usual operations in this region, there is, however, nothing of particular note in this chapter.

In the next chapter Boppe describes some of the rarer operations, including those required to remedy injuries inflicted on the ducts at previous operations. This is followed by a resume of the published cases under headings of the type of operation employed, giving the name of the surgeon, the journal in which the publication was made, and also the fate of the patient in each case. This is an excellent article on a very difficult subject.

In Chapter IX, Hartmann, Daniel Petit-Dutailh, and Ulrich discuss the immediate and late results of cholecystotomy, cholecystectomy, and choledochotomy. This is a very instructive and stimulating chapter. They show, and most surgeons will agree, that the results after cholecystectomy are a great improvement on those after cholecystotomy. They attempt to explain why it is that some patients con-

tinue to suffer after operations from minor discomforts such as flatulence, eructations, sluggish digestion, and heaviness in the hepatic region. In their opinion these symptoms are liable to appear in cases where the gall-bladder contains multiple stones or muddy bile, and are rarely seen where there are few and large stones, or where there is cholecystitis without stones, and particularly rarely in hydrops of the gall-bladder. They find that patients suffering from these minor ailments have urobilin in the urine and also a raised cholesterol content of the blood in 83.3 per cent, whereas patients who completely recover after operation show a rise in only 16.6 per cent. According to their view, and contrary to that of Chauffard, hypercholesterolaemia is not the cause of gall-stones, but the manifestation of an abnormality in the hepatic function. It disappears when the hepatic state returns to normal after the operation, it persists when, in spite of operation, the hepatic function remains altered. It seems to us that this is an interesting and important assertion, and one requiring confirmation.

The last three chapters are by Hartmann, and deal with indications for operation in diseases of the bile-passages, with the lesion described under the name of idiopathic cyst of the common duct, and, lastly, with carcinoma of the ampulla of Vater.

At the end of several of the chapters there is an adequate bibliography appended, and in the text views held by recognized authorities are given and commented upon. But the bulk of the work is compiled from the experience of Hartmann and his associates, and coming from such a source ought to be read by everyone whose daily work brings him constantly in contact with affections of the biliary tract.

The Pathological Physiology of Surgical Diseases: a Basis for Diagnosis and Treatment of Surgical Affections. By PROFESSOR DR FRANZ ROST, of the University of Heidelberg. Translated by S. P. REIMANN, M.D. of the University of Pennsylvania, with a foreword by JOHN B. DEAYER, M.D. 8vo. Pp. 535 + vii. 1923. Philadelphia: P. Blakiston's Son & Co. London: Stanley Phillips. 30s. net.

This is rather an unusual surgical book, and any review must be of a tentative character until its usefulness has been tested. The idea of the work seems to be the application of physiology to the study of disease. The author says in his preface, 'it is only by a broadening of physiological conceptions that progress in surgery may be expected.' That point may be conceded at once: surgery is not a question of technique, however well mastered. Surgery is a part of medicine, and, as such, a knowledge of anatomy, physiology, and pathology is essential, and it looks as if biophysics must soon be added to the list.

The aim of the book is to give information to the student and young surgeon concerning the vital and more recent physiological discoveries which may affect diagnosis and treatment of diseased organs. A most copious bibliography is appended to each chapter, thus, there are 260 references at the end of the chapter on the stomach, and 306 references to the intestines. The first effect is rather bewildering, and though one grants at once that an application of physiology to surgery is wise and sound, one wishes that the size of the book could have been diminished.

Hernia and its Radical Cure. By J. HUTCHINSON, F.R.C.S., Consulting Surgeon, London Hospital. Examiner in Surgery, Glasgow University, Formerly Professor at and an Examiner in Surgery to the R.C.S., London. Demy 8vo. Pp. 264 + viii, illustrated. 1923. London: Oxford Medical Publications. 12s. 6d.

THE radical cure of hernia is one of the most successful of all operations: one of the most frequently performed, and one of the greatest importance to the community. All surgeons can agree with this statement by the author in his preface. It is good also that a surgeon of such experience and reputation as Mr. Hutchinson should

emphasize the fact that the operation is not a minor one, and that its real success depends on painstaking technique rather than on rapid performance. It is well too, that all surgeons, however familiar with the operation, should take stock of their methods from time to time, and see whether they can be improved. This book may be recommended, therefore, to all surgeons young or old, for in it they will find a well-balanced review of all the ordinary methods of operation now in use.

Naturally there are a few points on which there may be differences of opinion—two of them may be mentioned here. The author has a predilection for kangaroo-tendon as the best material to be used for the hurried sutures. There is no doubt that kangaroo-tendon makes a good suture, but there is abundant proof that equally good results may be obtained with catgut, silk, or thread. Thousands of operations for hernia must be performed yearly throughout the civilized world, and one fears there would not be a sufficient number of kangaroo tails to go round if this form of suture were obligatory. The other difference of opinion concerns the best form of radical cure for a femoral hernia. Mr. Hutchinson prefers the older method of approaching the hernia from Scarpa's triangle, whereas the inguinal route appears now to find greater favour among the newer generation of surgeons. Both methods, however, are well described, and the point is open to argument.

Mr. Hutchinson is to be congratulated on a masterly exposition of an important subject and also on the fact that he has expressed himself clearly in a short compass.

A Practical Handbook on Diseases of the Ear. By SIR WILLIAM MURKIN, MD, F.R.C.S., F.R.S., and F.R.C.P., *Amnist and Laryngologist to the Royal Infirmary, Manchester; Consulting Surgeon to the Manchester Eye Hospital, and Visiting Physician to the Manchester Pathological Society.* (Litchy Physician) to the Central Throat and Ear Hospital, London. Demy 8vo. Pp. 191. Illustrated. 1923. London: William Heinemann Ltd. 12s. 6d. net.

It may be said at once that in their attempt to present the senior student of medicine with a concise account of the more ordinary diseases of the ear met with in general practice the authors have eminently succeeded in their task. Furthermore we feel sure that experienced otologists and pathologists will not read this excellent handbook without considerable profit to themselves. From cover to cover it provides the reader with a splendid resume of our present knowledge of diseases of the ear and their pathology. These are presented to the student in a clear, precise, scientific and withal easy style, and are illustrated by a series of, for the most part, excellent diagrams, drawings, and photographs.

Chapter I deals with the physiology of the ear, and is excellent. Chapter II is devoted to the examination of the ear, nose, nasopharynx, and pharynx. We are glad to note the authors' condemnation of most of the aural syringes on the market, which are useless or harmful because of their thick conical nozzles. It is difficult to conceive of a better description of the various tests employed in cases of deafness, but why do the authors speak of the Galton-Edelmann 'pfeifle' in one paragraph (page 22) and supply its English translation—whistle—in the next?

We would suggest that inflation of the ear through the Eustachian catheter (page 33) might be less painful to the patient in inexperienced hands if the Pontzer's bag (*Fig. 18*) were fixed to the catheter rather than to the rubber bottle illustrated in *Fig. 23*.

Chapters V and VI on diseases of the middle and external ear give the best description of their pathology, symptoms, and treatment with which we are acquainted. The illustrations are excellent, and here, as throughout the volume, the authors never fail to impress the reader with the need for paying due regard to the general health of the patient, e.g., chronic dysentery of the middle ear (page 116).

In Chapter X, "Exudation or Moist Catarrh of the Middle Ear", we should like to see emphasis laid on this condition as an almost constant sign of malignant disease of the nasopharynx. Again, the fine moist crepitations heard by the examiner

with the auscultation tube are a better diagnostic sign of the exudative catarrh than the 'dark line' on the membrane, which is frequently invisible.

Chapter XIV contains an excellent account of tuberculous disease of the middle ear—a subject which considering its importance has been too scantily discussed in most otological text-books.

Chapters XV and XVI give us a very complete and clear account of the suppurative lesions of the middle ear and their complications. The illustrations of operative procedures are just what are needed by the senior student and practitioner. Equally good is Chapter XX, which is devoted to labyrinthine suppuration.

In Chapter XXII will be found many useful formulæ for lotions, 'drops', inhalations, ointments, escharotics, dusting powders, etc. Possibly the greatest value of this chapter lies in the very useful information concerning the methods used in the examination of aural discharges and the various staining media which should be employed. The paragraphs which describe the method of lumbar puncture, and the morbid changes which the cerebrospinal fluid may exhibit under various conditions of disease are admirable.

We have only one adverse criticism to offer—namely, that the index is not so complete as it should be for such a valuable handbook.

Enlargement of the Prostate By JOHN B. DEANER, M.D., LL.D., Sc.D., F.R.C.S. John Rea Professor of Surgery, University of Pennsylvania, Surgeon in Chief to the Lankenau Hospital, Philadelphia. Assisted by LEON HIRMAN, B.S., M.D., Assistant Surgeon to the Pennsylvania Hospital, Philadelphia. Second edition. Medium 8vo. Pp. 358 + viii, with 142 illustrations. 1923. Philadelphia: P. Blakiston's Son & Co. \$7. London: Bale, Sons, and Danielsson.

THIS is a well-bound, clearly printed monograph. The authors have collected from their practice and from an extensive study of the literature nearly everything that is known, or thought, on this subject. The book is well illustrated, the references at the end of each chapter are most useful, and there is an index.

One naturally turns in a monograph like this to those pages that deal with the author's opinions on certain debatable points. Those who have read the recent work of Tandler and Zuckerkandl on the enlarged prostate will have been impressed by the numerous arguments they advance to prove the origin of enlargements of the prostate from that group of glands called the subcervical urethral. The authors refer to their work, and quote the observations of Lowsley on the embryology of the prostate, but do not accept their views, the reader is left a little puzzled to account for this non-acceptance, as the arguments the authors produce are not at all convincing. In Fig. 44 they represent the ejaculatory ducts as running through the substance of the enlarged gland, and not displaced posteriorly, it would be interesting to know whether this is a drawing from a dissection, or merely a diagram representing the authors' views on this subject.

There is a full discussion on the etiology of this condition, and it is interesting to find that the one factor that is common to almost every case is the age of the patient.

Another section which every surgeon will study is that dealing with the comparative value of the various tests of the kidney function. They state that Ambard's constant and cryoscopy have not met with much favour in America. They seem to place most reliance on the phthalein test and estimation of the blood-urea, but state emphatically that they are all very largely guided by the general condition of the patient. In discussing the latter, one is surprised to find no reference to the condition of the tongue.

Although the authors do not expressly state it, certain facts seem to emerge after a study of this section of the book.

1. In spite of the emphasis laid on the value of an estimate of the patient's general condition this is not to be relied on, otherwise there would be no necessity for the numerous tests of kidney function.

2 In spite of the authors' defence of the phthalein test, this has proved to be absolutely unreliable. They quote case after case from their own experience and from the literature where a patient with an excellent phthalein output has, after prostatectomy, promptly died of uræmia, also cases where the patient, in spite of a very scanty output (which has continued scanty after a preliminary cystotomy), has been operated on and made in excellent recovery.

3 It seems unreasonable to assume that the combination of two unreliable factors, the general condition of the patient and his reaction to the phthalein test, should produce a certainty in diagnosis and nothing short of this is of any use to the patient.

4 The blood-urea test seems to some surgeons the most direct and reliable of the tests yet invented, but time alone will show if it is absolutely good from the point of view of prognosis in these cases of prostatectomy.

There is an excellent chapter on the indications for radical treatment by suprapubic or perineal prostatectomy, and the authors' remarks on the advisability in some cases of a two stage operation, and on the arrest of bleeding after operation are worth reading. Few modern urologists will agree with the authors' view that there are cases in which the clipping off of a projecting middle lobe is all that is necessary.

Encyclopædia Française d'Urologie Edited by Dr A. POISSON, Professeur à la Faculté de Médecine de Bordeaux, and Dr E. DISSOS, Secrétaire Général de la Société Internationale d'Urologie. Vol V pp 1110 and VI pp 1086 1922 Paris Octave Doin. Vol V and VI, each 60 fr., Vols I to VI, complete, 300 fr.

THESE two compendious volumes, comprising in all 2196 pages, form parts of an important work on urology by various French authors. The scheme of the work is that the literature of each subject is collated and a very extensive bibliography is given at the end of each chapter. The views and methods of many authorities are concisely given without interfering unduly with the thread of the narrative.

Volume V has 1110 pages which are entirely devoted to diseases of the urethra. Among many important articles may be noted examination of the methyln and urethroscopy by Nogues and Papin, some excellent coloured illustrations being included. Stricture of the urethra and its complications is described in 215 pages by Esert, and further space is devoted to the technique of operations on the urethra by Nogues, Hertz Boyer, and Genonville.

Volume VI deals in 1086 pages with diseases of the prostate and urinary symptom. It contains chapters on the examination of the prostate, the calculus, and cysts (Craisson), malignant tumours (Panchet), tuberculosis (Erbischhoff), etc.

The extent and thoroughness of the work may be gauged by the fact that the article on hypertrophy of the prostate by Marion extends to 187 closely printed pages, with an additional 16 pages for the bibliography. In this section the author gives an account of the present knowledge of simple enlargement of the prostate and its treatment. In another section he describes the operative technique he personally adopts. The section on urinary symptoms includes such mechanical conditions as retention and incontinence of urine (Delbet), and abnormal conditions of the urinary secretion and composition, such as muria, phosphaturia, oxaluria, glycosuria, etc.

It is impossible to discuss the various subjects in detail, but it may be said that the thoroughness with which the literature is collated and the high standard of the discussion, are maintained throughout. These volumes form, with the others which have already appeared, one of the most extensive and authoritative publications on urology at the present time. They should form a part of the reference library of every urinary surgeon, and may be recommended to the notice of physicians studying the medical aspects of urinary disease.

Cancers du Rein de la Glande Surrénale, et des Voies Urinaires Supérieures
By P. LECRNE, Professeur à la Faculté de Médecine de Paris and G. WOLFROMM
Préparateur à la Faculté de Médecine de Paris Roy 8vo Pp 212, with 32 illustrations 1923 Paris Gaston Doin 15 fr

THIS is one of a series of monographs on cancer—*Bibliothèque du Cancer*—published under the direction of Professors Hartmann and Bernaid, of which cancer of the intestine has already been issued, and two others are in the press thyroid cancer and cancer of the rectum

This monograph gives an excellent account of the tumours of the kidney, adrenal and ureter, it is well illustrated, and some of the microscopical sections are admirably reproduced. We do not think it contains much new material, but it may be consulted as an epitome of what is known on this subject.

Perhaps the most striking point in this book is the following quotation from the preface to the second edition "It is an impressive fact that the operation which we advised in the previous edition should be performed only after all palliative means have been tried without success, is now justifiable as a primary procedure, and one far safer in the average case than any form of palliation." With this statement surgeons on this side of the Atlantic heartily agree, provided that the patient is not already the subject of a painless retention nor the victim of injudicious catheterization.

Particularly interesting and full descriptions are given of tumours of the pelvis of the kidney and of paraneoplastic new growths.

Chirurgie Vasculaire Conservatrice By P. MOURE, Chirurgien des Hôpitaux de Paris
Crown 8vo Pp 144 + v, with 110 illustrations 1923 Paris Masson et Cie 12 fr

THIS book belongs to a series of medical monographs appearing from time to time according to the needs of the moment. The object of the work is to show that suture and grafting of blood-vessels should be removed from the domain of experimental surgery and taken into everyday use. The first part is descriptive of the technique of blood-vessel suture, and the second of the indications and applications to human surgery. The work is well done, clearly illustrated by diagrams, and should prove of practical use to any one interested in this line of surgery.

Medical Practice in Africa and the East Edited by HUGH MARTIN, M.A., and H. H. WEIR, M.A., M.B., with an introduction by STEPHEN PAGLT, F.R.C.S. Crown 8vo Pp 111 + vi 1923 London Student Christian Movement 4s net Paper covers, 2s 6d net

THIS is an interesting and well written account of 'pioneer' practice in the outlying districts of the world where modern science is still unknown. The scope is shown by the sub title which runs, 'a series of open letters on professional subjects from doctors practising abroad, addressed to their colleagues at home'. The letters prove how much can be done by earnest-minded men, well skilled in the medical profession, who are willing to sacrifice their own comfort for the good of their fellow-creatures and to lay up for themselves treasure "where neither rust nor moth doth corrupt". By those young men and women who have such an ideal the book will be bought and eagerly read.

SHORT NOTES ON BOOKS

Surgical Dents and 'Dogs' By C. HAMILTON WHITEFORD, M.R.C.S., L.R.C.P.,
Hon Surgeon to the Plymouth Infirmary Crown 8vo Pp 46 London Harrison
and Sons Ltd 3s

A small book full of practical wisdom some of which is wisely said.

Topographische Anatomie dringlicher Operationen By J. LANDIER, Professor of Anatomy, Vienna. Second edition. Pp. 118, with 56 figures. Berlin: Julius Springer. 8s. 6d.

This small book is intended to present the anatomical picture of those regions in which operations of emergency may have to be performed. It is concerned with ligature of arteries, and with abdominal, chest, and urogenital surgery. The great feature which recommends it is the very beautiful half-tone and coloured illustrations. These are so good that we would wish for a larger work on the same lines dealing with the surgical anatomy of the whole body.

Grundriss der gesamten Chirurgie, ein Taschenbuch für Studierende und Ärzte By Professor LUDWIG SONNEN, Leipzig. Second edition. Pp. 937. Berlin: Julius Springer.

This is a very closely-printed and much-condensed synopsis of surgery. It includes an account of general surgery, special surgery, and a summary of operative surgery. It represents a very great amount of information compressed into a small space and is certainly of value for purposes of reference.

Surgical Nursing and After-treatment: a Handbook for Nurses and others By H. C. RIMMORF DARRING, M.S., F.R.C.S., Surgeon, Coast Hospital, Sydney. Second Edition. Pp. 566, with 138 illustrations. London: J. & A. Churchill. 8s. 6d.

This book is written in accordance with the syllabus of the Australian Trained Nurses' Association. It is a treatise on elementary surgery as well as a careful text-book of surgical nursing. The style and printing are clear and the illustrations are simple and well chosen. It concludes with a useful appendix giving weights and measures, diets, etc.

THE BRITISH JOURNAL OF SURGERY

VOL. XI

JANUARY, 1924

No 43

EPONYMS

By SIR D'ARCY POWER, K B E, LONDON

XI BELL'S PALSY.

THE account of Bell's Palsy appears in the second part of the *Philosophical Transactions of the Royal Society of London* for the year 1821, pp 398-424. Contribution XXVIII is entitled "On the Nerves, giving an account of some experiments on their structure and functions, which lead to a new arrangement of the system. By Charles Bell, Esq. Communicated by Sir Humphry Davy, Bart, P R S, read July 12, 1821." Bell decided of set purpose to ascertain the course and determine the functions of the nerves of respiration. 'The first point of enquiry', he says, "naturally is, how many of the muscles are combined in the act of respiration? and the second question, By what means are these muscles, which are seated apart from each other, and many of them capable of performing distinct offices, combined together in respiration? It may sound oddly to speak of the respiratory nerve of the face, of the neck, and of the shoulder, but when a post-horse has run its stage, and the enunciation is hurried, what is his condition? Does he breathe with his ribs only, with the muscles which raise and depress the chest? No. The flanks are in violent action, the neck as well as the chest is in powerful excitement, the nostrils as well as the throat keep time with the motion of the chest. So if a man be excited by exercise or passion, or by whatever accelerates the pulse the respiratory action is extended and increased, and instead of the gentle and scarcely perceptible motion of the chest, as in common breathing, the shoulders are raised at each inspiration, the muscles of the throat and neck are violently drawn, and the lips and nostrils move in time with the general action, and if he does not breathe through the mouth, the nostrils expand, and fall in time with the rising and falling of the chest, and that apparatus of cartilages and muscles of the nose (which are as curious as the mechanism of the chest and which are for expanding these air tubes) are as regularly in action as the levator and depressor muscles of the ribs. It is quite obvious that some hundred muscles thus employed in the act of breathing, or in the common actions of coughing, sneezing, speaking and singing cannot be associated without cords of connection or affinity, which

combine them in the performance of these actions the nerves which serve this purpose I call respiratory nerves"

After considering some points in the comparative anatomy of the nerves Bell enumerates the following as *respiratory nerves* in accordance with their functions —

"1 *Par vagum*, the eighth of Willis, the *pneumogastric nerve* of the modern French physiologists

"2 *Respiratory nerve of the face*, being that which is called *portio dura* of the seventh This nerve like the last goes off from the lateral part of the *medulla oblongata*, and, escaping through the temporal bone, spreads wide to the face All those motions of the nostril, lips or face generally, which accord with the motions of the chest in respiration, depend solely on this nerve By the division of this nerve the face is deprived of its consent with the lungs and all expression of emotion This part of the enquiry will be found very interesting

"3 *Superior respiratory nerve of the trunk* being that which is called *spinal accessory* This nerve has exceedingly puzzled anatomists from the singular course which it pursues

"4 *Great internal respiratory nerve* The *phrenic*, or *diaphragmatic* of authors This is the only nerve of the system which has been known as a respiratory nerve

"5 *The external respiratory nerve* This has a similar origin with the preceding nerve It comes out from the cervical vertebrae and is connected with the *phrenic nerve* It runs down the neck, crosses the cervical and axillary nerves, passes through the axilla, and arrives on the outside of the ribs, where, it is scarcely necessary to observe, the muscles are already supplied by nerves coming out betwixt the ribs from the system of regular nerves

"These four last-mentioned nerves govern the muscles of the face, neck, shoulders and chest in the actions of excited respiration, and are absolutely necessary to speech and expression But there are other nerves of the same class which go to the tongue, throat, and windpipe, no less essential to complete the act of respiration These are the glossopharyngeal nerve, the lingual, or ninth of Willis, and the branches of the *par vagum* to the superior and inferior larynx"

These nerves are then considered in detail He says "of the respiratory nerve of the face, being that which is called *portio dura* of the seventh (*Portio dura nervi acustici*, *Sympatheticus parvus* by Winslow, *Faciale* by Vieq d'Azzyr) Plate *Aabcd* This nerve does not exist except where there is some consent of motions established betwixt the face and the respiratory organs In fishes, this nerve, instead of being distributed forward to the face, passes backward to the muscles of the gills In fact there is, properly no *portio dura* of the seventh in fishes, the nerve resembling it being a branch of the *par vagum* A short description of this nerve in the human body will be necessary to our enquiry" Bell traces its anatomical course from the superior and lateral part of the *medulla oblongata*, through the temporal bone, to its distribution on the face He states that in texture it corresponds with the structure of the *par vagum* and differs from that of the *trigemini*



DRAWING BY SIR CHARLES BELL TO ILLUSTRATE
THE RESPIRATORY SYSTEM OF NERVES

The function he arrived at experimentally "An ass being thrown, and its nostrils confined for a few seconds, so as to make it pant and forcibly dilate the nostrils at each inspiration, the *portio dura* was divided on one side of the head, the motion of the nostril of the same side instantly ceased, while the other nostril continued to expand and contract in unison with the motions of the chest

"On the division of the nerve the animal gave no sign of pain, there was no struggle nor effort made when it was cut across

"The animal being untied and corn and hay given to him he eat without the slightest impediment

"An ass being tied and thrown, the superior maxillary branch of the fifth nerve was exposed Touching this nerve gave acute pain It was divided, but no change took place in the motion of the nostril, the cartilages continued to expand regularly in time with the other parts which combine in the act of respiration, but the side of the lip was observed to hang low and it was dragged to the other side The same branch of the fifth was divided on the opposite side, and the animal let loose He could no longer pick up his corn, the power of elevating and projecting the lip, as in gathering food, was lost To open the lips the animal pressed the mouth against the ground, and at length licked the oats from the ground with his tongue The loss of motion of the lips in eating was so obvious that it was thought a useless cruelty to cut the other branches of the fifth

"The experiment of cutting the respiratory nerve of the face or *portio dura*, gave so little pain that it was several times repeated on the ass and dog, and uniformly with the same effect The side of the face remained at rest and placid during the highest excitement of the other parts of the respiratory organs When the ass, on which the respiratory nerve of the face had been cut, was killed, which was done by bleeding, an unexpected opportunity was offered of ascertaining its influence, by the negation of its powers on the side of the face where it was cut across

"When an animal becomes insensible from loss of blood, the impression at the heart extends its influence in violent convulsions over all the muscles of respiration, not only is the air drawn into the chest with sudden and powerful effort, but at the same instant the muscles of the mouth, nostrils and eyelids and all the side of the face, are in a violent state of spasm In the ass where the respiratory nerve of the face had been cut, the most remarkable contrast was exhibited in the two sides of its face, for whilst the one side was in universal and powerful contraction, the other, where the nerve was divided remained quite placid

"From these facts we are entitled to conclude, that the *portio dura* of the seventh, is the respiratory nerve of the face

"The actions of sneezing and coughing are entirely confined to the influence of the respiratory nerves When carbonate of ammonia was put to the nostrils of the ass whose respiratory nerve had been cut that side of the nose and face where the nerves were entire, was curled up with the peculiar expression of sneezing, but on the other side where the nerve was divided, the face remained quite relaxed although the branches of the fifth pair and the sympathetic were entire The respiratory nerve of one side of the face

of a dog being cut, the same effect was produced, the action of sneezing was entirely confined to one side of the face

"On cutting the respiratory nerve on one side of the face of a monkey, the very peculiar activity of his features on that side ceased altogether. The timid motions of his eyelids and eyebrows were lost, and he could not wink on that side, and his lips were drawn to the other side, like a paralytic drunkard, whenever he showed his teeth in rage

"We have proofs equal to experiments, that in the human face the actions of the muscles which produce smiling and laughing are a consequence of the influence of this respiratory nerve. A man had the trunk of the respiratory nerve of the face injured by a suppurative abscess which took place anterior to the ear and through which the nerve passed in its course to the face. It was observed that in smiling and laughing, his mouth was drawn in a very remarkable manner to the opposite side. The attempt to whistle was attended with a ludicrous distortion of the lips, when he took snuff and sneezed, the side where the suppurative abscess had affected the nerve remained placid, while the opposite side exhibited the usual distortion

"Thus it appears that whenever the action of any of the muscles of the face is associated with the act of breathing, it is performed through the operation of this nerve. I cut a tumour from before the ear of a coachman, a branch of the nerve which goes to the angle of the mouth was divided. Some time after he returned to thank me for ridding him of a formidable disease, but complained that he could not whistle to his horses."

Bell then proceeds to examine the function of the fifth nerve, and shows that it is sensory by evidence derived both from experiment and clinical experience, and then "having brought this investigation to a conclusion some perhaps, fatigued by its details, may ask to what does this discussion lead?"

"Were we to enquire no further and to rest content with the inference that the two sets of nerves distributed to the face have distinct functions even this must prove useful to the surgeon and physician. To the surgeon it must be useful in performing operations on the face, as well as in observing the symptoms of disease, but especially to the physician must these facts be important, he will be better able to distinguish between that paralysis which proceeds from the brain, and that partial affection of the muscles of the face when, from a less alarming cause, they have lost the controlling influence of the respiratory nerve

"Cases of this partial paralysis must be familiar to every medical observer. It is very frequent for young people to have what is vulgarly called the blight, by which is meant, a slight palsy of the muscles on one side of the face, and which the physician knows is not formidable. Inflammations of glands seated behind the angle of the jaw will sometimes produce this. All such affections of the respiratory nerve will now be more easily detected, the patient has a command over the muscles of the face he can close the lips, and the features are duly balanced, but the slightest smile is immediately attended with distortion, and in laughing and crying the paralysis becomes quite distinct. The knowledge of the sources of expression teaches us to be more minute observers."

Sn Charles Bell afterwards collected the various papers upon the nervous system and published them with some alterations and in greater detail in a single volume which ran through several editions. It is clear that his views were not received favourably at first, for in a clinical lecture on a case of facial paralysis he says "I remember very well many years ago, when these ideas on the nervous system first occurred to me, that I took the opportunity of explaining them to a great philosopher (Dr Young) who was respected as a man of almost universal information and great intelligence. I took to him the class drawings from which these are copies. Captain Katei, who was present, was very desirous to understand the whole doctrine. I began by saying, 'The respiratory nerves of the face'. Dr Young was in bad health, and irritable. He said, 'Who ever heard of respiration of the face?—that will never do'. He would not hear of the idea of respiration of the face. No wonder, as a chemical philosopher, he had only been accustomed to think of respiration as connected with the great function of the oxygenation of the blood. It was a new idea to him to think of the act of respiration as connected with the face." This is a remarkable testimony to the novelty of Bell's views, for Dr Thomas Young, "the founder of physiological optics" who was equally great as a physicist and as an Egyptologist, was a man of universal erudition. Captain Katei, the Treasurer of the Royal Society, is still remembered by the extraordinarily accurate seconds pendulum which he invented, as well as by the fact that he prepared the standard measures for the Russian Government in 1815.

The novelty of Bell's teaching sometimes reacted unfavourably upon his pupils, for "A young gentleman went up to the College of Surgeons in order to pass. He was examined by my excellent friend Mr Abernethy, who was then in all his vigour of mind, but who was ever a little sarcastic. He asked this young man to tell him the parts that combined in the act of breathing, and when he had enumerated the common parts, he added, 'the muscles of the pæneum'. At which Mr Abernethy sneered and repeated, 'Pæneum! what has that to do with it?' My young friend proceeded to explain, that, although in the common act of respiration the muscles there were not concerned, yet that in all violent exertments of respiration such as in coughing, sneezing and straining, he had been taught (and he believed correctly), that unless there was a combined action there, the parts would be protruded, that unless the muscles at the opening of the pelvis were in correspondence with the diaphragm, there could be no protection of the viscera, but a protrusion of it. He added, 'I am sensible there is a corresponding action every time I cough or sneeze'." Sn Charles Bell gives no indication of Abernethy's reply, but considering the plain speaking of the time, it is perhaps better left to the imagination.

The illustration is copied from Sn Charles Bell's own drawing engraved by Basne for the *Philosophical Transactions*.

OPERATION SHOCK *

By JOHN FRASER, EDINBURGH

OPERATION shock or surgical shock is one of the formidable developments which every now and again jeopardize and even nullify the best surgical efforts. As we have learnt more regarding its origin and pathology its ravages have been correspondingly crippled yet the evidences are sufficiently manifest to make it a very real danger. It is one of those factors which has delayed and curtailed the evolution of surgical progress, and were it possible to eliminate its appearance, the surgical horizon would correspondingly enlarge, and the fulfilment of many surgical dreams might be realized.

In the surgery of childhood, in the surgery of accident and in that most extreme form of accident surgery—the surgery of war surgical shock has ever played a formidable part. Therefore a condition which has so limited our surgical progress, sullied our best efforts, and increased our mortality must surely demand the closest attention.

The subject is one of the widest consideration, it is replete with problems both clinical and physiological, and the exact nature of much of it is still unknown to us. We get an idea of the complexity of the problem when we attempt to summarize the steps by which our knowledge of the subject has accumulated, and with this aim in view it is convenient to divide the progress of our knowledge into two periods—(A) to the end of 1915 and (B) subsequent to 1915. This second period has been distinguished by the opportunities which the misfortunes of the European war afforded for the study of the condition, and the corresponding efforts which various scientific bodies made to elucidate and to combat the problem.

A—PERIOD TO THE END OF 1915

It may be said that during this period opinion had tended to crystallize round certain individual theories, and, though many of these views have suffered eclipse, we may learn something from a short consideration of the more important.

1 The Theory of Exhaustion of the Vasomotor Centre—This view came to be and is still, associated with the names of Cùlle¹ and Mummery². It was argued that sensory stimuli produce a rise of blood pressure from the irritation of 'pressor nerves', and the continuation of such afferent stimuli leads eventually to exhaustion of the vasomotor system, dilatation of the peripheral vessels, and a subsequent fall of blood pressure. In regions in which only a depressor afferent nerve exists (as in the testis for example), stimulation results in a correspondingly great degree of shock.

* Read at the Sixth Meeting of the International Society of Surgery in London, in July, 1923.

This theory suffered from two destructive criticisms—that the vessels in shock are contracted (Maleolm,³ Seelig and Lyon⁴), and that it can be demonstrated experimentally that even in the most profound shock the vasomotor centre is not exhausted (Seelig and Lyon⁴, Porter and Qumley⁵)

2 The Acapnia Theory (Yandell Henderson)—The activity of the respiratory centre is largely governed by the amount of CO_2 in the blood, an excess of CO_2 produces stimulation of respiration, a diminution of CO_2 results in several deep respirations and a pause in the respiration, which is known as 'apnoea'. According to Henderson,⁶ the deep and rapid breathing which has a painful stimulant effect so reduces the CO_2 that a condition (acapnia) results which is the primary cause of shock. Secondary to the acapnia it was assumed that there was a failure of the venous pressure, an accumulation of blood in the venous spaces, impoverishment of the right auricle, and a resulting fall in blood-pressure.

In confirmation of his view Henderson has quoted experiments by Sherington and Copeman⁷ which seem to indicate that a diminution of CO_2 results in a tendency for fluid to pass from the blood plasma into the tissues, leaving the blood concentrated. The sequence which is assumed in Henderson's theory may be summarized thus: hyperpnoea, acapnia, failure of the vasomotor pressure mechanism, fall of blood-pressure, and possibly a secondary concentration of the blood (ohgæmia).

It must be of interest to the abdominal surgeon to recall how Henderson demonstrated what he believed to be a local manifestation of his view. He claimed that when the abdomen is opened and the intestines exposed, there is relatively a great loss of CO_2 from the visceral surfaces, a loss which he estimated as forty times as great as that from the skin. Locally this change was manifested by vascular dilatation, muscular paresis, apnoea, and eventually by general manifestations of surgical shock.

Based upon his conception of the physiological pathology, Henderson instituted a programme of treatment for shock which included slow respiration, breathing through a long tube, so that expired air loaded with CO_2 was re-breathed, pouring warm saline saturated with CO_2 into the abdominal cavity, transfusing warm saline saturated with CO_2 , and allowing the subject to breathe in and out of a bag containing an O_2 oxygen.

While the Cline-Mummeley and the Henderson theories found most acceptance, there were other views, of which only a summary need be given.

3 The Boise Theory—Boise⁸ regarded the fall in blood-pressure as being secondary to a cardiac condition, and he believed that there was a tendency for the heart to fail in systole. As we shall show, there is abundant evidence that the cardiac condition is never the primary fault in true surgical shock.

4 The Meltzer Theory—The foundation of Meltzer's⁹ theory is based upon the supposition that the stimulus of injury resulted in an inhibition of the functions of the spinal cord, and in the more extreme degrees in an inhibition of the medulla and its centres. This view seems to have originated in the demonstration of the clinical fact that, when the abdomen is opened, or even when an extensive skin dissection is made, there is a resulting inhibition of the intestinal peristaltic movements. No reliable experimental evidence

seems to have been produced which supports the possibility of such being a reflex spinal inhibition

Other views which have been held only demand a passing notice. Certain of them contain what one may term 'partial truths'. Kinnamann¹⁰ believed that disturbances of the thermogenic functions played an important and a primary part, Jaboulay¹¹ attached importance to the formation of an indurible hæmoglobin, Bainbridge and Parkinson¹² suggested that the loss of chromaffin tissue which can be manifested in shock might be a responsible feature, Schur and Weisel¹³ demonstrated a similar loss of chromaffin tissue after anaesthesia, and suggested the relationship of this fact to shock. Vale¹⁴ described the concentration of the blood (oligæmia) which is recognized in the later stages of shock and at one time it seemed as though this fact held much of the secret of shock, Bissell¹⁵ described the occurrence of severe shock in relation to pulmonary fat embolism and he suggested that such a mechanical error might be a constant feature in the condition.

The above summary may be said to represent the various attitudes of opinion to the problem prior to 1915.

B —PERIOD SUBSEQUENT TO 1915

The second stage in the attempt at elucidation of the shock problem was distinguished by the occurrence of the European war. The serious manifestations of the disorder which then became evident began to arouse widespread attention. Reports from the various centres of war made constant allusion to the ravages of shock and to the high mortality which it claimed. Early in 1916 a carefully organized effort was made to elucidate the problem, and in this country the Medical Research Committee undertook the task. It is to this body and to various observers who were associated with it that we owe much of our present knowledge.

A Definition of Shock—Before we can appreciate the various changes which appear to play a part in the complex problem of the shock condition it is essential that we have some concrete definition of what the term 'surgical shock' implies. Such a definition is difficult, especially if it is to be in any way inclusive, but surgical shock may be defined as *a state of depression of all the vital functions of the body, the state being primarily induced by the infliction of injury on the body tissues, and being characterized by a progressive fall of the blood-pressure*.

The Clinical Features—The clinical features which develop as the result of surgical shock vary according to the degree of the shock, but in a well-established case they may be grouped somewhat as follows. The individual may be described as being in a state of prostration. Mentally he is apathetic and indifferent, it is with difficulty that he can be roused from his apathy, and yet when roused he can answer clearly and intelligently though faintly. The face is pale and drawn, the eyes are sunken, the cheeks hollow, the lips and ears pallid or dusky in appearance, and beads of perspiration may stand out on his face. The skin has a grey, dusky appearance, and it is cold and clammy to the touch, the musculature shows evidences of depression in the languid character of its movements. The pulse is rapid and fluttering, and

it may be all but imperceptible at the wrist. The respiration is shallow, sighing, and irregular, and a noticeable feature is the low temperature of the exposed an. The mouth is parched, there is an intolerable thirst, and an impressive feature in the picture is the diminished sensibility to pain. Such are the collective evidences which we conveniently group under the term 'surgical shock', and the picture justifies the definition, because it is no other than a devitalization of all the essential and vital functions of the body.

The exciting factor of the train of symptoms is trauma of some description whether it be accident, wound, or surgical operation, and one of the most impressive features in the condition is the rapidity with which an active, healthy man is converted into a collapsed and helpless invalid.

THE CLINICAL PATHOLOGY OF THE STATE OF SHOCK

It is reasonable that we should ask ourselves the explanation of the development of this remarkable and often sudden transformation. I believe it was Professor Cannon¹⁶ who first suggested that it is convenient to arrange the disturbances of shock into four groups—(1) *Circulatory*, (2) *Respiratory*, (3) *Motor*, and (4) *Sensory*, and if we now attempt to explain the individual changes in each of these group disturbances, we may be able to obtain an accurate idea of the series of errors which are at work. This would appear to be a more rational way of considering the problem than of attempting to prove or to disprove any individual theory.

1 The Circulatory Disturbances—The essential demonstrable error as far as the circulation is concerned is the progressive and often sudden fall of the blood-pressure. Other features, which are obviously secondary to the blood-pressure change, are the small, rapid pulse, the pallor of the body surface, and the low temperature of the skin. The problem, therefore, is to explain the progressive fall of the blood-pressure. In a condition of health there are three factors which maintain the blood-pressure at a normal level: (i) The contracting heart, (ii) The vasomotor mechanism, which controls the tonicity of the vessel walls, and (iii) The blood-volume, an error in one or other of these would explain the fall in blood-pressure. Let us therefore inquire whether it is possible to locate the error.

1 The Heart—It was suggested by Howell that a paralysis of the cardio-inhibitory centre might occur in shock, the effect being to produce an increase in the rapidity of the heart-beat and therefore a weakening of its efforts. The experiments of Mann¹⁷ however, have shown that this suggestion has no foundation, for even in the most profound degree of shock stimulation of the central end of the cut vagus resulted in a reflex slowing of the heart. There are also two clinical facts which disprove any possibility of error in the nerve mechanism of the heart: (a) If adrenalin is administered during deep shock, it will be found that the heart begins to miss beats owing to the stimulation of its inhibitory centre by the adrenalin, and (b) Where shock is associated with a head injury which results in an increase of intracranial pressure, the heart is slowed owing to stimulation of the cardio-inhibitory centre even though the shock may be profound.

There is therefore abundant evidence that as far as the nerve mechanism

of the heart is concerned, no error is to be found. It remains to consider the possibility of the heart muscle being the responsible feature.

Mann's¹⁸ experimental work supplies the answer to this query, because he has shown that, apart from myocardial disease, an efficient contraction of the cardiac muscle can be guaranteed as long as the heart is properly supplied with blood. The persistence of the low blood-pressure in established shock will of course result in myocardial weakness, but in this event the change is secondary. The low blood-pressure is therefore not traceable to any error in the heart or its related nervous mechanism.

ii *The Vasomotor Mechanism* — It was a natural assumption that the low blood-pressure might be due to a relaxation of the walls of the arterioles, and certain of the accepted theories of shock were founded upon this assumption. We have the evidence of many observers, however, that the fault does not lie in this direction. The vasomotor centre is capable of response in fully-established shock (Seelig and Joseph¹⁹, Guthrie²⁰). It is possible that on receipt of the injury there may be a temporary functional inhibition of the centre, but there is no evidence of a progressive exhaustion of it through a reflex origin. Cule and Dolley²¹ have described histological evidence of exhaustion of nerve-cells in the central nervous system, a process in which presumably the vasomotor centre might share, but there is a growing belief that these changes (chromatolysis) are produced by anemia and are not the result of harmful afferent stimuli (Mott).

Assuming that the error does not lie in the vasomotor centre the possibility has to be considered of the low blood-pressure being due to a relaxation or to a paralysis of the muscular tissue of the arterial or venous system, more especially of the splanchnic vessels. We find, however, that the possibility has been denied and it is asserted by Malcolm² and others that the vessels are actually contracted during shock.

Those who have had an opportunity of performing abdominal operations during deep shock are unanimous in denying the possibility of a splanchnic dilatation, and as a matter of fact, the pallor which is so characteristic of shock is rather an indication of vascular contraction than of any degree of dilatation. The evidence which we possess, therefore, is in favour of the vasomotor centre and its associated connections remaining active during the introductory stages of shock.

iii *The Blood-volume* — A diminution in the volume of blood in circulation would explain the low arterial pressure of shock, and in view of the fact that the heart with its associated nervous mechanism and the bulbovasomotor centre appear to be unimpaired, suspicion very naturally falls upon the factor. In the vital-red method we have at our disposal a means of estimating the blood-volume, and the investigations of Keith,²² Robertson and Bock,²³ and others have shown that when shock is established the blood-volume in active circulation is reduced. This therefore would seem to be the explanation of the low blood-pressure which so characteristically distinguishes the circulatory changes.

The observer is now driven back to the question. Why is the blood volume in active circulation reduced? It is doubtful if a complete answer to the question is yet available. Cannon has put the question in an appropriate

form when he speaks of "the problem of the lost blood", and a similar impression is implied when we speak of a shocked individual having 'bled into his own vessels'.

There are two localities in which blood might collect in sufficient volume to effect a reduction of the blood-pressure—the splanchnic area and the capillary area. The splanchnic was long considered to be the situation in which blood collected during shock, and there are both anatomical and physiological reasons which made the possibility a likely one; but we have been driven from this conclusion by the evidence of the practical surgeon, that during deep shock the splanchnic vessels are actually contracted instead of being dilated.

There remains therefore the capillary system. It has been demonstrated that when an individual suffers from shock the red blood-count taken from the superficial capillaries is considerably higher than that taken from the veins. The more profound the shock the greater is this discrepancy, so that in profound shock the capillary count may exceed the venous by as much as 2,000,000 corpuscles per cmm. Since the venous count is approximately normal, one has to conclude that there is a stagnation of corpuscles in the capillaries. The results obtained by enumeration can be controlled and confirmed by hæmoglobin and hæmatocrit estimations.

Our knowledge of the capillary system is incomplete. The recent work of Krogh²⁴ gives some idea of the vast possibilities of the system in the establishment and in the maintenance of disease. The idea that it is merely a finely divided mechanical connection between the arterial and the venous systems must be abandoned—it is an independent system, and as such is susceptible to influences to which it responds in a variety of ways.

When we appreciate the fact that one-tenth of the muscular bulk of the body is composed of capillary tissues we begin to realize how immense is the influence of the system on the establishment of disease. It would appear, in short, that the deleterious influences which have been at work have so affected the capillary system that its vital activities are depressed, and the comparatively large space of the capillary tissue becomes a catchment area in which a proportion of the fluid blood is prevented from passing into the general circulation.

There is in fact evidence to show that the fall in arterial blood-pressure, which is such a distinctive feature of surgical shock, is due to a reduction of the volume of blood in active circulation, and that this diminution in volume is the result of the withdrawal from active circulation of a proportion of blood which stagnates in the capillary circulation.

2 The Respiratory Disturbances—The distinctive character of the respiration in shock is that of a superficial, rapid type, with occasional deep sighs and at intervals a quick respiratory flutter. It may be recalled that Henderson in his acapnia theory claimed that the respiratory change was a primary factor in shock because an extreme pulmonary ventilation so diminished the CO_2 content of the blood as to produce what he termed an 'acpna' which resulted in the circulatory and other phenomena of shock. If this view is correct the body in the early stages of shock should show a diminished amount of CO_2 but Janeway and Ewing²⁵ have proved that the CO_2 content is not reduced, and this observation has been confirmed by others.

It must therefore be accepted that the respiratory changes are not primary, but are secondary to the influence of other factors. The first of these factors exists in the low blood-pressure, and therefore in the diminished O_2 carrying power of the blood which we have described in connection with the circulatory disturbances. A reduction in the amount of O_2 provided by the blood for the central nervous system results in an instability of the various nerve-cells and centres, which is reflected in the rapid respiration of shock.

The second factor which may explain the respiratory changes is a natural sequence of the first. Owing to the ineffective nature of the shallow breathing which results from the imperfect supply of O_2 there is an abnormally high CO_2 content of the blood and at the same time there is, for reasons which are discussed later, a reduction of the body alkali—in fact the combination of changes may be spoken of as an increase of the hydrogen-ion content. Now Haldane and Priestley²⁶ have shown how extraordinarily sensitive the respiratory centre is to an increase of the hydrogen-ion content and the type of respiration which results is of a rapid and deep character. In the later stages of shock the shallow respiratory type of the early stage is replaced by intervals of a rapid, deep and gasping character.

The third influence which may effect the respiratory change is of a more hypothetical nature, it is the exaggerated Hering-Breuer reflex described by Haldane²⁷. In normal respiration as the lungs are being stretched by the action of the respiratory muscles certain nerve-endings or 'receptors' are stimulated, and it is this stimulation which inhibits inspiration and excites expiration. Under certain conditions the inhibitory stimulus occurs early in the course of inspiration, and a rapid shallow respiration naturally results. Surgical shock, in common with hæmorrhage, appears to have the effect of so altering the reflex.

We may therefore summarize the respiratory changes as follows. The characteristic respiration of shock is of a rapid shallow character, in the later stages it becomes deep and rapid, and the factors which induce these changes are the low arterial pressure with its associated decrease of the O_2 -carrying power of the blood, possibly an alteration of the Hering-Breuer reflex, and in the later stages of shock an increase of the hydrogen-ion content of the blood, with direct stimulation of the respiratory centre.

3 The Motor Disturbances—An increasing motor weakness extending into muscular apathy is distinctive of the 'shocked' condition. It has been suggested that these changes result from repeated sensory stimuli which being converted in the central nervous system into motor impulses, lead eventually to physiological block in the motor tract. Sherrington²⁸ has proved this possibility. He has shown that, if stimuli are repeated so as to produce a block in the afferent paths, and therefore a failure in the reflex, the reflex is at once produced if a new afferent path is chosen. The motor mechanism is less affected than the sensory in repeated stimulation.

The explanation of the motor changes in shock is to be found in the low arterial pressure. Gruber has shown that when the systolic pressure is reduced below 90 mm, the muscles as contractile organs become less capable of work, and the whole central nervous system shares in an impaired nutrition secondary to the lowered blood-pressure, the afferent tracts and sensory cells, the

synapse, motor cells and tracts are equally affected. It is therefore not surprising that in the victim of shock there is a general relaxation of the body musculature, irregular and feeble movements, and a slowing and weakening of central nervous functions.

These remarks are intended to apply more especially to striped or voluntary muscle, involuntary or non-striped muscle, such as the alimentary canal, is also inhibited, but its inhibition has a different explanation from that of voluntary muscle. In the case of the non-striped muscle the inhibition would appear to be due to activity of the sympathetic nervous system.

4 **The Sensory Disturbances**—Diminished sensibility to stimulation is one of the most striking clinical evidences of shock. Sherrington offers the explanation that the afferent impulses are blocked at the junction or synapse between the afferent neurones and the neurones which he wholly within the central nervous system. The phenomenon of 'blocking' he accounts for as being due to an increase of the natural resistance at the synapse to such a degree that the impulses fail to pass. When an explanation is demanded as to why there should be increased synaptic resistance associated with shock we find it in Porter's experiments on the effect of low arterial pressure. Porter studied the effect of low blood-pressure on the minimal strength of the stimulus required to evoke a reflex in the spinal cord, and he found that with a uniform level of arterial pressure the threshold stimulus for the reflex remains practically uniform. If the blood-pressure is lowered the threshold rises, synaptic resistance increases, and a greater strength of stimulus is required to evoke a response. In Porter's experiments the minimal stimulus rose from 40 to 110 units as a result of lowering the blood-pressure. Whether the question of lowered arterial pressure is read as a diminished amount of O_2 or as an increased amount of CO_2 does not appear to matter, for both conditions have the effect of raising the synaptic threshold.

There is, however, another explanation of the diminished sensibility in shock, in connection with motor disturbances we have drawn attention to Sherrington's experiments, in which he demonstrated that, apart from considerations of blood-pressure, repeated afferent stimuli eventually give rise to a sensory block by producing an increased synaptic resistance.

The evidence which we possess, therefore, indicates that the sensory disturbances of shock are the result of an increased synaptic resistance, which in its turn proceeds from excessive stimulation along afferent tracts and from a continued low blood-pressure.

The Causes of the Production of the Low Blood-pressure—It will be observed that running throughout the various clinical manifestations of shock, whether circulatory, respiratory, sensory, or motor, there is the common thread of a low blood-pressure. Not only does this state explain in large measure the various clinical evidences, but it is the starting-point of a vicious circle to which allusion will be made later. It is therefore important that we should consider any evidence which we have in explanation of the low arterial pressure.

1 **Nervous Causes**—Of the exact way in which nervous influences act upon the blood-pressure we know very little but in different types of individual

and under varying conditions remarkable alterations of blood-pressure may be recorded. In certain individuals a low blood-pressure is a normal state, and in most of us the reactionary period which follows an interval of strain is associated with some degree of hypotension. We have noticed that the blood-pressure of a soldier in the trenches recorded 110 mm (systolic), while the same individual in rest billets registered 100 mm (systolic). Underlying this fact there is the suggestion that the state of hypotension which is a natural sequel to any period of strain is a time of danger from the point of view of the inauguration of shock. There are many obvious practical applications of this point in relation to surgical operations, etc.

2 *The Influence of the Absorption of Toxic Products from Damaged or Infected Tissues*—Sir Cuthbert Wallace has emphasized the increased liability to shock when large muscular masses are cut. He contrasted the degree of shock after interscapulo-thoracic amputation with that after amputation at the hip-joint, the degree being considerably greater in the latter because of the relatively large amount of muscle which is divided. The experience of the war confirmed this view, and it also drew attention to the frequent association of severe shock with compound fracture of the thigh and multiple wounds. Such observations as these have been made the basis of experimental investigations by Bayliss and Cannon²⁹. They found that within an hour after producing a compound fracture of the femur in an anesthetized cat, the fracture being accompanied by bruising of the large flexor muscles of the thigh, the animal showed signs similar to those which one associates with surgical shock. The blood-pressure gradually fell, pulse-rate and respiration increased, the blood showed signs of concentration, and the animal finally succumbed.

The next stage in the experiment was to isolate the limb from the central nervous system and subsequently to traumatize it in the way described. The sequel was exactly similar, and this result definitely excluded the possibility that harmful effluent stimuli from the injured limb were responsible for the symptoms.

When, however, the third stage of this experiment was carried out and the return of blood from the damaged limb was prevented by means of small clips, there was no resulting fall of blood-pressure, but as soon as the clips were removed and the returning blood reached the body, the blood-pressure fell. We must assume that the muscle destruction resulted in the liberation of a tissue-poison which, circulating in the blood, produced the fall in blood-pressure.

The question naturally arises as to how the tissue-poison acts in producing this effect. Vincent and Sheen³⁰ found that extracts of muscle have a specific effect in producing vasodilation, and Dale and Richards³¹ showed that histamine dilates the capillaries, they suggested that substances of similar action are produced by injury to tissues. The result of a widespread capillary dilatation would be the 'side-tracking' of a considerable amount of blood into them, and the loss of this amount of blood to the general circulation would act very similarly to a hæmorrhage by producing a lowering of the blood-pressure.

3 *The Influence of Cold*—Prolonged exposure of the body to cold has an undoubted effect in lowering the blood-pressure, and its influence is probably

greatest when the tension has begun to fall from the effect of some other deleterious influence, in which case it acts as an aggravating feature in further reducing the arterial pressure. It would seem that the cooling of the body surface results in a retardation of the blood-flow through the superficial capillaries—this directly leads to a diminished supply of blood to other regions of the body, the lowering of the temperature increases the viscosity of the blood, and thereby the blood-flow in the capillaries is still further retarded. The influence of this combination of features invariably leads to a progressive fall in blood-pressure.

4 *The Possible Influence of the Internal Secretions*—The theory was at one time advanced that exhaustion of the suprarenal bodies played an important part in reducing the blood-pressure and so inaugurating the cycle of shock. It was suggested that strong emotional influences either led to a primary deficiency or produced a temporarily higher secretion and a resulting hyposecretion. Our evidence on this point is not conclusive. Cannon³² and Elliot³³ have been able to demonstrate the presence of adrenalin in the blood of wounded men—in individuals, therefore, who, it may be supposed, suffered in some degree from shock. Bedford confirmed a similar finding in experimental shock. It is interesting to notice that the experimental injection of large doses of adrenalin produces a shock-like condition with an associated fall in blood-pressure.

It is possible that the suprarenal secretion, perhaps in common with the secretion of other ductless glands, may exert an influence upon the introductory phenomenon of shock, but any influence which they may possess is more likely to be of a secondary nature, and therefore demonstrable when metabolism is seriously interfered with.

5 *The Influence of Anaesthesia*—The administration of an anaesthetic is associated in the early stages of anaesthesia with a rise of blood-pressure, but this is soon succeeded by a gradual fall. At first the decline is very gradual, but after the anaesthetic has been in use for a certain period of time the fall becomes more rapid, and this state of hypotension may well be, and frequently is, the starting-point of a grave post-operative shock, the danger is all the more real because such influences as tissue injury, cold, hæmorrhage, and emotion may coincidentally be exerting their influence. Of the various anaesthetics, chloroform appears to be the most dangerous in this respect.

6 *The Influences of Hæmorrhage and Sepsis*—No elaboration of these influences is necessary—the effect of hæmorrhage is self-evident. There appears to be a definite limit up to which a pressure compensation is possible but when this point is reached the fall is rapid and maintained. We perhaps attach insufficient importance to the influence of sepsis on the blood-pressure. Any general infection, whether a toxæmia or a septicæmia, is associated with hypotension and it would seem that the anaerobic infections are especially harmful.

The Sequence of Events after a Low Blood-pressure has been Established—From whatever cause the lowering of the blood-pressure has proceeded the effect of the change is to set in action a series of events which ultimately leads to a derangement of the various processes of body metabolism.

1 *Deficient Oxygenation of the Body Tissues*—A continued low blood-pressure necessarily implies a diminished O_2 supply to the various body tissues and such an unnatural state of affairs is reflected in the institution of what one may term a physiological pathology of the cells and their products. The cells individually may be structurally damaged, while the products of their activity are in a state of incomplete metabolism and this is frequently synonymous with a condition of toxicity.

2 *Capillary Stasis*—The effect of a persistently low blood-pressure is to encourage a general capillary stasis and the first stage of a vicious circle is thus begun, for capillary stasis results in diminished oxygenation of the tissues, while the diminished oxygenation still further aggravates the capillary delay and it is an obvious sequence that a further fall of blood-pressure will ensue.

3 *The Development of Acidosis*—Normal blood plasma contains a certain percentage of sodium bicarbonate, and this constitutes the alkali reserve of the blood and one of the alkali reserves of the body. A reduction of this alkali reserve is spoken of as an 'acidosis' (L. J. Henderson, Van Slyke). The term is also used in another connection which it is important to explain. The bicarbonate of the blood plasma contains a weak acid in the form of dissolved CO_2 (H_2CO_3) and the relationship between the acid and the alkali is expressed in terms of what has been called the hydrogen-ion concentration. If the bicarbonate ($NaHCO_3$) decreases while the CO_2 increases or remains constant, it is said that the hydrogen-ion concentration rises (acidosis), if the CO_2 decreases while the $NaHCO_3$ remains constant or increases, the hydrogen-ion concentration falls, if both vary together so that the proportion to one another remains constant, the hydrogen-ion concentration is unchanged. There can be no doubt that in shock an acidosis develops and it would seem that at first it is in the sense of a reduction of the bicarbonate content of the plasma, while at a later stage there is an actual increase of the hydrogen-ion concentration.

The question has arisen as to whether the acidosis, the existence of which is beyond dispute, should be regarded as a determining factor in the cycle of shock symptoms (in other words, an essential cause) or whether it is a secondary result of a progressive circulatory deficiency. The question is best answered in certain of the conclusions which have been arrived at in Report No. 7 of the Shock Committee (Medical Research Council).

1 Acidosis in the sense of a simple reduction of the bicarbonate of the blood plasma is not the *cause* of shock or even an important factor in its production.

2 A progressive uncompensated fall of the alkali reserve is the result of an inadequate oxygen supply to the tissues.

3 Oxidation of the tissues is more easily rendered inadequate by defective circulation through the capillaries than by a reduction of the O_2 -carrying power of the blood.

4 The fall of the alkali reserve is a *symptom* of a deficient capillary circulation and not a *cause* of such.

5 To some extent the fall of the alkali reserve in its early stages is a protective measure, its protective action being through stimulation of the

bulbar centre, but in the later stages, as the hydrogen-ion concentration increases, the protective action disappears.

This important, and in some respects vital metabolic derangement of shock is therefore, distinctly traceable to a capillary stasis, and this in its turn is dependent as we have shown, upon a low blood-pressure and its concomitant factors.

GENERAL CONCLUSIONS AS TO THE NATURE OF SURGICAL SHOCK

The essential underlying factor in the production of the 'shocked' condition is a prolonged and progressive fall in blood-pressure. The causes which inaugurate the original fall are various, some are nervous, some are clinical in many instances there is a combination of causes. hæmorrhage, sepsis, and the absorption of toxic products from injured tissues are collateral and sustaining factors of great influence. With the establishment of a persistently low blood-pressure something of the nature of a vicious circle comes into play, the prolonged hypotension leads to imperfect oxygenation of the body tissues, and to a capillary stasis, the capillary stasis reduces the amount of blood in active circulation, and the imperfect oxygenation of the tissues results in the formation of various toxic products from imperfect tissue metabolism. These influences collectively further reduce the blood-pressure, the vicious circle is maintained, and the tendency is for it to continue to a fatal issue unless some link in the chain is broken and the hypotension error is overcome.

SOME CONSIDERATIONS OF TREATMENT

In view of the full consideration which has been given to the clinical aspects of the problem it is only possible to summarize the more important details of treatment. As far as possible the considerations are arranged under individual headings.

1 Estimate the Degree of Shock which is Present—Considerations of prognosis and subsequent treatment make it essential that we possess some knowledge of the degree of shock which is present. The simple clinical observation of the patient's appearance and pulse-rate affords a certain amount of information but this is unreliable, and the only exact estimation which we have is by recording the systolic blood-pressure, a systolic pressure which registers 90 mm or less indicates such a degree of shock that immediate restorative measures are necessary.

2 Exclude the Possibility of Hæmorrhage or Sepsis simulating True Shock—It may seem unnecessary to record this piece of advice, but the error is frequently made of mistaking the evidence of hæmorrhage or sepsis for true surgical shock. To concentrate upon the treatment of shock while these independent influences are at work is to court inevitable failure.

3 The Importance of Warmth—If we appreciate the importance of capillary stasis in the pathology of shock we are in a position to realize how vital it is to ensure warmth to the individual who is exposed to the possibility of shock. The deleterious influence of cold is especially dangerous when the individual is unconscious or under the influence of a general anaesthetic. We have seen an individual exposed to such an amount of chill during a surgical

operation that at the conclusion of the operation the temperature of the interior of the thigh muscles was 91° . The influence of such a low body temperature in the development of shock must be enormous.

4 **The Importance of Fluid**—If our estimation of the pathology of shock is correct it is dangerous to limit in any degree the administration of fluids. A high fluid consumption has an influence in maintaining blood-pressure; it tends to diminish oligæmia and therefore capillary stasis, while its certain benefits are the dilution and removal of the deleterious imperfect metabolic products. If the oral administration of fluid is for any reason impossible the other avenues are employed. In view of the importance of the reduction of the blood alkali in shock, diachym doses of sodium bicarbonate should be given at intervals in combination with the fluid.

5 **Food**—Starvation is to be avoided in both the prevention and the actual treatment of shock. Food should be allowed if there is an appetite for it, unless some special contra-indication exists and foods of high carbohydrate content are essential.

6 **Sleep and Rest**—There can be no doubt regarding the wonderful restorative benefits of sleep. A natural sleep is of course the best and therefore the patient should be kept in comfort and quietness and shaded from strong light.

In many cases sleep must be induced and this is best accomplished by morphia. It is a debatable point to what extent the administration of this drug may be pushed, Crile advocates repeated doses until the respirations are reduced to twelve per minute, but it has been maintained that such reduced respirations increase the risk of acidosis and the consensus of opinion is in favour of the administration of morphia to a point when pain and restlessness are relieved, and no further. The fact must be kept in mind that, with a rise of blood-pressure, a natural sleep often follows.

7 **Drugs**—Adrenalin and strychnine two former standbys in the treatment of shock, are now condemned as useless and possibly dangerous. Pituitary extract may produce a temporary benefit from its stimulating effect on the cardiovascular system but there is no continued advantage from its use, and repetition of the drug is dangerous. Alcohol has no real stimulating effect, and the only excuse for its administration will be its use as a body food. Digitalis and camphor are useful as temporary stimulants, oxygen should be administered if there is any evidence of cyanosis; it also relieves restlessness and the an-hunger of the late stages of shock, glucose and bicarbonate of soda are of value if there is evidence that an acidosis is impending or has developed.

8 **Transfusion**—The essential feature in the development of shock being the fall in blood-pressure various remedies are directed towards raising it, and naturally an intravenous infusion of fluid is the most rapid and effective method at our disposal. The question arises as to the type of fluid which should be used.

a Saline Solutions—Normal saline has been for many years the fluid in most common use, but we now recognize that its beneficial effect is only a transient one. Its intravenous injection in large quantities produces dilution of the blood and an increase in its total volume, the kidneys, the skin, and

the lymph channels excrete the excess of fluid, there is profuse perspiration, and presently the blood is actually less in bulk and more concentrated than before. Its benefit is therefore a very temporary one, and eventually its use may do more harm than good. Similar remarks apply to Ringer's solution and its various modifications.

b Colloidal Solutions—In Bayliss's gum-saline solution (6 per cent gum acacia in 0.9 per cent sodium chloride) we have a fluid for intravenous injection which has proved of enormous value in practical use. In his most recent publications on the subject, Bayliss³⁴ speaks of it as follows—

The most important factor in the treatment of wound shock is the ensuring of an adequate supply of blood (that is, of oxygen) to vital organs, especially to the nerve centres. This is most easily done by the intravenous injection of a 6 per cent solution of gum acacia in 0.9 per cent sodium chloride in order to increase the volume of blood in circulation and to raise the arterial pressure.

The technique of transfusion and infusion does not concern us, it is only necessary to say that one pint of the solution should be given to begin with, and it ought to be given as early as possible after shock has begun to develop. If within half an hour only partial benefit is apparent, a further injection may be made. It is advisable to give the infusion slowly, fifteen minutes being required for the introduction of a pint. The solution should be warmed to blood heat.

Erlanger and Gasser advise the use of a 25 per cent gum in 18 per cent dextin. This mixture results in a very viscid solution, and clinically the results have not been as good as those with Bayliss's solution.

c Blood Transfusion—In cases of shock where there has been the complicating factor of severe hæmorrhage, the transfusion of human blood gives most excellent results. The method may be used in shock apart from hæmorrhage, but it is in the cases where there has been loss of blood that the results are most striking. The majority of surgeons are agreed that the citrate method of transfusion is the safest and most reliable.

d Preserved Blood-corpuscles—Based upon the researches of Abel, Rous, and Turner,³⁵ the injection of blood-corpuscles preserved in a citrate-dextin solution may be employed. The solution may be kept in ice for as long as three weeks and the results obtained have been encouraging.

The Influences of General Anæsthesia and Surgical Operation upon Shock—If, during the progress of a surgical operation of any magnitude, certain investigations are made, it will be found that three changes have appeared—

- 1 There is a lowering of the systolic blood-pressure.
- 2 Examination with the hemato-crit shows a gradually increasing concentration of the blood.

- 3 There is a reduction of the alkali content of the plasma.

In fact during the progress of the operation there has been the inauguration of the three processes which have such an important influence upon the institution of the shocked condition. In the large proportion of cases these various changes are so slight that little clinical evidence of their presence is apparent but none the less they are the basis of shock, and under unfavourable

conditions they may assume dangerous proportions. If the development of these features is to be kept within the limits of safety (then complete avoidance is impossible) certain precautionary measures are necessary, and these may be summarized as follows —

1 Operation on a case which shows persistent low blood-pressure should be delayed, if possible, until means have been taken to raise the blood-pressure.

2 The operative procedure should be as short as is consistent with thoroughness.

3 The operation should be carried out with the least possible interference and trauma. Every effort should be made to avoid unnecessary loss of blood.

4 'Chilling' of the patient before, during or after the operation must be avoided.

5 If it is possible to exercise a choice of anæsthetic, nitrous oxide and oxygen should be chosen.

6 If simple restorative measures have failed to raise the blood-pressure before operation it ought to be raised artificially by the intravenous infusion of human blood or of 1 pint of 6 per cent gum-acacia solution in normal saline.

7 If examination of the blood shows that a condition of acidosis is present before operation, a reserve of alkali should be built up by the intravenous infusion of 1 pint of 4 per cent solution of sodium bicarbonate.

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REPORT OF THE DISCUSSION ON OPERATION SHOCK

AT THE INTERNATIONAL SURGICAL CONGRESS, LONDON JULY, 1923

THE discussion on operation shock was opened by Cile, of Cleveland, Ohio USA. The paper in which the subject was introduced was an ingenious exposition of what he termed "the electro-chemical interpretation of shock and exhaustion". The living body was visualized as a complex and elaborated combination of electro-chemical elements and as the body is built up of an infinite number of individual cells, correspondingly great is the combination of electro-chemical arrangements because each cell of the body possesses its own individual and peculiar electrical arrangements. The electric energy which the cell displays is dependent for its source upon the process of oxidation and the hypothesis was presented that the cell nucleus is electrically positive while the cytoplasm is negative. Cile expressed his appreciation of the point in the following words —

"Cells have the power of oxidation only as long as there is a difference in the potential between the nucleus and the cytoplasm and a difference in potential is maintained only as long as there is oxidation"

The idea which the sequence is intended to convey may efficiently and perhaps more accurately, be expressed by the accepted truism that efficient oxidation is essential for the health and well-being of the individual cell.

Cile proceeded to elaborate the fact that for efficient oxidation two things are essential—oxygen and water. The oxygen is necessary for the combustion which the process implies, the water is the vehicle by which the O_2 is brought into contact with the cell while it carries away the acids which result from the process of oxidation, in fact it is the vehicle of the restoration of the acid-alkali balance of the body. As the process of oxidation reaches its highest level in the nucleus of the cell, any electrical current which exist will flow from the point of higher potential (the nucleus) to that of the lower (the cytoplasm), from this idea the further elaboration was made that a somewhat corresponding difference in potential exists between individual organs of the body, the brain is regarded as the site of the highest potential—the positive pole—the liver the negative pole—the nerves the connecting wires and the salts in solution the electrolytic fluid in which the electro-chemical mechanism is immersed. In such an arrangement it is assumed that, since electricity flows from a higher to a lower potential, and since oxidation is highest in the brain, oxidation electric waves pass down the nerves from the area of higher potential within the brain to the areas of lower potential in the muscles and glands, and since the liver has the lowest rate of oxidation—hence the lowest potential—the current would finally reach that area, whence it would return by the electrolytic system to the brain, thus completing the

cient Such may be said to be the conception of vitality as imagined by Crile

The author reviewed the more recent work which has been attempted in connection with the etiology of surgical shock and his conclusion was that, while there is uniformity of opinion in regard to the end-results of shock—alteration in blood-pressure, diminution in the alkali reserve, changes in the H-ion concentration of the blood—in no instance has any real knowledge been brought forward which throws light upon the actual cause of shock. It would seem as though every known method of physiological investigation has been brought forward without avail. In face of this Crile and his co-workers have turned to their conception of the electro-chemical arrangements of the body, and in disturbance of these they believe they have found the explanation of the phenomena of shock and exhaustion.

In shock, in exhaustion, and in other associated phenomena it is believed that three changes are apparent—

- 1 Changes in the electrical variation and conductivity of the tissues
- 2 Changes in histological structure as revealed by certain methods of staining
- 3 Changes in functional activity as evidenced by variations in temperature dependent upon alteration in oxidation, and demonstrable by the use of the thermocouples

The change which would appear to be the starting-point in the combination of features collectively associated with shock is a lowering of the difference between potentials in individual cells and relatively between potentials of different body structures. Such a lowering of the potential ratio is probably dependent upon an error in the process of oxidation, in which case the oxidation failure is more truly the primary cause of the disturbance, and as the brain is the most important site of oxidation, and therefore the chief source of electrical energy, interference with its functions results in secondary changes throughout the entire body. In consequence of the change in electrical variation there are the resulting errors of depression of functional activity, and demonstrable histological changes.

Crile would define shock as the ultimate result of a deepening degree of exhaustion, the exhaustion being primarily “the result of a diminution of the difference in potential between the poles of the organism due to a decrease in the potential of the brain, which in turn results from a decreased difference in potential in its constituent cells.” “This conception explains the identity of the phenomena of exhaustion and the progressive degrees of exhaustion to shock.” “When the difference in potential reaches zero the organism is dead.”

The paper concluded with a clinical application of the conception that man is an electro-chemical mechanism, and the following well-accepted principles were urged—

1. The organism needs an abundant supply of fresh water
2. An abundant supply of oxygen must be delivered to the cells
3. The permeability of the selective semi-permeable membranes must be maintained within a normal range

- 4 Both the local and the general temperature of the body must be kept at or near the normal
- 5 An abundance of mental and physical rest and an abundance of sleep are essential
- 6 The physical structure of the cells must not be impaired by the indirect effects of the trauma of the operation or by the anæsthetic

By the practical application of these principles the two essential factors (O₂ and water) in the maintenance of the integrity of the electro-chemical system are assured, provided recovery is anatomically possible and the disintegration of the cells has not progressed to the early stages of inevitable dissolution, that is provided the acid-alkali balance—the difference in potential—within the cells is maintained or restored, and then internal respiration is protected.

The practical application of the above principles is achieved—especially in bad-risk cases—by the following measures —

1 Nitrous oxide analgesia (not anæsthesia) in combination with local anæsthesia

2 The two-stage operation if it is found that a primary interference is being badly tolerated

3 Water is administered by every possible route in order to ensure sufficient hydration of the cells. 3000 cc is routinely given by hypodermoclysis by Bartlett's method

4 Oxygenation of the cells is promoted by the transfusion of whole blood before during and after operation according to indication

5 Digitalis is administered routinely in all cases in which the myocardium is impaired, in order to ensure the maintenance of an adequate circulation

6 Rest and sleep are promoted by attention to the environment and by narcotics except in cases in which jaundice exists, in these latter cases the already depressed liver-cells would be further injured by the use of morphia

7 In abdominal cases moist hot packs are applied immediately after operation "for the support of the liver-cells"

If justification of these methods is required, it is found in the mortality statistics which Cile quoted. "During the period from 1919 to the present date (April 1, 1923) the mortality-rate of the surgical service at Lakeside Hospital has fallen from 24 to 12 per cent, the mortality-rate of the last 500 ligations has been 0.8 per cent, and of the last 500 thyroidectomies for exophthalmic goitre 0.6 per cent."

The discussion was continued by Quénu, Duval, and Mocquot (Paris), who in collaboration contributed a paper upon a clinical study of shock. The conclusions at which they arrived may be summarized as follows —

A Various theories which attempt to explain shock as arising from a primary derangement of the nervous system are false, and such theories fail to tally with the results of clinical observation

B They believe —

1 That they have been able to demonstrate a close relationship between the destruction of large tissue masses and the development of surgical shock

2 That microbial infection plays no part in the primary development of shock

3 That the condition which magnifies the train of shock symptoms is actually the wounding of the tissue and thus apart from any question of the influence of the nervous system

4 That the early excision of the wound focus may prevent the development of shock or at least so improve the evidences of it that recovery follows in the most desperate cases

5 That the clinical observations and results are in support of the hypothesis that shock owes its primary development to the absorption of harmful products from a wound or area of tissue destruction

The reporters proceeded to discuss the etiology of shock as they understood it. They recalled the well-recognized influence of crushing or bruising of the tissues, they showed that severe injury unaccompanied by tissue destruction (as, for example, in avulsion of a limb) may be unaccompanied by shock and they further discussed the secondary influence of cold hemorrhage and fatigue.

From a clinical basis they proposed to subdivide shock into three groups—immediate, primary, and secondary. Immediate shock is rare and in war work at least it was difficult to separate examples of true immediate shock from somewhat similar conditions which owed their development to hemorrhage or poison gas. The stage of primary shock was defined as that which exists up to the time when organismal infection may first become evident—it is probably due to the absorption of noxious products from the injured tissue of the wounded part. The evidences may become apparent within thirty minutes of receipt of the wound, and under special conditions of temperament or fatigue its manifestations may be even more rapid. The stage of secondary shock was recognized as practically synonymous with that of septic absorption from the infected wound.

The authors described a series of investigations which they had carried out in connection with the clinical manifestation of the so-called 'primary shock'. A fall of temperature was considered to be the most distinctive feature, and the inference was made that such a derangement of temperature was the direct result of the absorption of the injured tissue products. Lowering of the blood-pressure was the second distinctive feature quoted. An account was given of the blood investigation, it was recorded that during this stage of shock there is an increase of the various nitrogenous substances of the blood, and especially of the residual nitrogen (a diminution of the alkali reserve). Examination of the urine with a view to explaining the nitrogen blood changes revealed changes of considerable importance, the principal being a fall in the urea output and a diminution in the urine bulk.

The clinical progress of the shocked condition follows one of two lines—the symptoms may gradually deepen, those of septic absorption succeeding those of primary shock until a fatal issue develops, or, on the other hand, improvement may appear suddenly or gradually, and synchronous with the improvement there is a urinary 'crisis' in which the fluid output is raised and the urea content increased.

A portion of the paper was devoted to consideration of prognosis. Evidences of temperature and of blood-pressure were not considered of great value, but importance was attached to the results of the blood and urine examination, especially in regard to the relative urea content of each.

The paper concluded with an account of the author's experience in the treatment of shock. In view of the importance which they paid to the influence of toxic absorption it was not surprising to find that the suppression of such absorption formed the basis of their line of treatment. Prophylactic measures were urged and these included the maintenance of the body heat, the immobilization of the injured limb, the arrest of hæmorrhage, and the employment of a tourniquet, partly to prevent hæmorrhage but even more important, to minimize the absorption of toxic products from the injured area. With this last consideration in mind, the use of antitoxic sera was recommended, and also the 'fixation' of the injured tissues by such chemicals as formalin.

Symptomatic treatment included the increasing of the body temperature, and the raising of the blood-pressure by intravenous injection of blood, gum, or saline. The causal treatment of shock necessarily embodied early removal of the focus from which the toxic absorption proceeded—amputation when a limb was irreparably damaged, excision of suitable wounds.

Fraser (Edinburgh) discussed the problem of shock from a clinicopathological aspect—the paper is reported fully in the present issue.

In view of the fact that a low blood-pressure is the most distinctive and the most constant evidence of the shocked condition, an attempt was made to explain its occurrence. It was believed to depend upon a reduction of the blood volume in active circulation, and the explanation of the reduction was to be found in a capillary stagnation. Special attention was paid to the hitherto unappreciated importance of the capillary system in the development of shock and possibly of other types of cardiovascular disease. The various circulatory, respiratory, motor, and sensory manifestations of shock were traced to the essential influence of the hypotension. The paper included an account of the various prophylactic and active measures in the treatment of shock.

Pauchet (Paris) contributed a communication upon the results which he had obtained in the treatment of shock by the transfusion of pure oxygenated blood. He considered such a method infinitely preferable to that of the citrated blood transfusion. The donor's venous blood is passed into a vessel containing oxygen, and it is then shaken up until it has acquired the characteristics of bright arterial blood. The special advantages claimed for this method include—

- 1 The immediate increase in blood-pressure
2. The maintenance of the high pressure owing to the fact that the blood does not readily pass through the vessel walls
- 3 The stimulating effect of the oxygen contained in the blood upon the central nervous system and upon the endocrine glands
- 4 The suppression of acidosis which the oxygen ensures. A shocked individual whose blood-pressure registered 90 or lower was invariably treated on this plan. The records of 300 cases were reviewed, and the results were exceedingly promising.

Uffeduzzi (Turin) gave the results of four series of animal experiments with the object of studying the problem of 'autotoxic' shock. Extracts of pounded or of finely-divided muscle were injected, and investigations were carried out on the blood-pressure, the respiration, the pulse, and the blood

analysis. The author's experience was that the injection of muscle extract in such an amount as to represent the probable degree of absorption from an injured area produced none of the typical changes of shock. Temporary arrest of the venous circulation was without any influence on the development. Injection of muscle previously infected with organisms resulted in death but no shock evidences accompanied the change. On the other hand deep shock ensued when the testes were crushed or the sciatic nerves were bruised. From such researches the author concluded that shock is entirely of sympathetic nervous origin, it may be that chemical and toxic influences exert a secondary effect, but no evidence was found in support of the primary influence of absorption from an area of bruised or wounded tissue.

Zawadzki (Warsaw) alluded to the shock effects which are manifest during certain manipulations under general anaesthesia. These he ascribed to nerve influences transmitted from the field of operation and in the correction of them he advised the blocking of the tissue around the field of operation by injection of magnesium sulphate and the administration of morphia and atropine in combination with general anaesthesia.

He recalled the importance of observing the blood-pressure throughout the course of a surgical operation. Adrenalin, caffeine, and injection of serum were advised as suitable for the treatment of the shocked condition when it had become established.

Juasek (Prague) recorded the results of studies upon shock produced by abdominal operation. Anaesthesia, cold and infection add their deleterious influence to the effects of traumatism of the viscera. Juasek made two groups of observations, one with subjects under general anaesthesia the other under paravertebral anaesthesia, and in both instances he observed a degeneration of the chromaffin cells of the suprarenal capsule. He discussed the probable influence of such a change upon the manifestation of shock, and the conclusion to which he came was that the suprarenal changes exert an influence upon the development of the 'shocked' condition.

**SURGICAL AND PARASITOLOGICAL NOTES
ON FOUR CASES OF INTESTINAL OBSTRUCTION
DUE TO ACCUMULATION OF VERY LARGE NUMBERS OF
ROUND WORMS (*Ascaris Lumbricoides*)**

By JOSEPH J. LEVIN AND ANNIE PORTER JOHANNESBURG

THE present paper is written in two sections. The first, on the surgical aspects, is by the first-named author, while the second gives brief parasitological notes on the ascariides found, and is by the second author.

I. SURGICAL NOTES (J. J. LEVIN)

During the period between May, 1920 and May, 1923, there have occurred at the General Hospital, Johannesburg, four cases of acute intestinal obstruction due to large—one might almost say enormous—numbers of round worms (*Ascaris lumbricoides*) and although cases of intestinal obstruction due to round worms have been recorded, yet in the limited literature at my disposal I have not been able to find records of such 'massed' obstruction (nor had one thought it consistent with life) as is revealed in these four cases. With two of them I was associated personally (Cases 1 and 3), on Case 3 I operated myself. Dr. Dauth operated on two of the cases and Dr. Biebnier on one, and I am indebted to these gentlemen for their permission to use their notes and publish them.

Case 1—A Hottentot boy, 11 years of age, inmate of a reformatory, who came under my care as medical officer in that reformatory. The history was that the boy had been convicted in the Eastern Province for theft, and had been sentenced to five years' detention in a reformatory in the Eastern Province of the Cape Colony. When admitted to the reformatory he was apparently in normal health, but later on he was reported sick, and was found to be suffering from phthisis. The medical officer there thought the boy might thrive better at the higher altitude of Johannesburg, and he was transferred to the Diepkloof reformatory, near Johannesburg. He was kept under observation in the reformatory hospital for nearly two months, and was so well that he was put on to light labour, consisting of picking up grass and papers. After he had been discharged from the hospital for a couple of weeks, I was sent for hurriedly to see him on the afternoon of May 4, 1920, and I obtained the history that his bowels had not moved for three days, and that he had vomited a couple of round worms and had also passed a couple per anum. The boy looked extremely ill, and his abdomen was distended and as tight as a drum. His temperature was subnormal, his pulse 136. I made the diagnosis of acute obstruction either by a ball of worms or by tuberculous glands, and brought the boy to the General Hospital, Johannesburg,

having previously arranged that he should be taken straight to the operating table. Prisoners, as a rule come under the care of the superintendent of the hospital, and in his absence the case was dealt with by Dr Dauth the senior Resident Medical Officer.

With a middle-line incision Dr Dauth opened the abdomen, and immediately there presented to him three or four feet of small intestine (jejunum) dilated to about three times the normal thickness and tightly packed with what proved to be round worms. The intestine was incised longitudinally in two places for a length of about 22 in. and 571 round worms were evacuated from the bowel. Subsequently 18 more worms were recovered from the boy per os and per anum (*Fig 262*). He was treated with santonium. The intestine was sutured and the abdomen closed without a drain. The worms were taken to Dr Annie Porter Parasitologist to the South African Institute for Medical Research and her report is given on page 137. The boy made an uninterrupted recovery, and was discharged from hospital on June 21. I subsequently obtained his pardon and he was liberated from the reformatory, since when I have not been able to obtain any further history.

Case 2—A European girl age 9 years an inmate of an orphanage was admitted to the General Hospital on May 29, 1920 with a provisional diagnosis of acute appendicitis, and with a history that at 9 a.m. on May 28 while running about and playing she complained of pain in the abdomen. She continued to walk about as usual all that day and at night vomited three times. On the morning of May 29 a doctor was called in who sent her into hospital. In hospital the history was elicited that her bowels had not moved for two days. The abdomen was swollen and hard, and it was quite impossible to obtain any information from the examination, as her abdomen was very tender all over. There was marked hyperæsthesia. There was no noticeable lump anywhere. Her tongue was dry and furred, her temperature 97.1° , and her pulse 160. A diagnosis of perforated appendix with general peritonitis was made. Dr Biehn opened the abdomen and found the large bowel acutely congested in patches. He removed the appendix, in which there were two round worms. He found the jejunum completely obstructed by round worms for a distance of several feet from the duodenojejunal flexure. He opened this portion of the jejunum longitudinally in two places about a foot apart, and evacuated 'several hundred' worms. The intestine was sutured and the abdomen closed. After the operation the patient was collapsed, and did not retain the rectal salines which were administered. The next day she passed five worms per rectum and two per os. She died in the afternoon, never having responded to the treatment for shock.

Case 3—A European girl age 8 years, an inmate of the same orphanage as the previous case, was admitted to the General Hospital on April 14, 1923, with a diagnosis of acute appendicitis (?) and a history of having been ill for four days. Her tongue was furred, her temperature 98° , and her pulse 120. The house surgeon on duty sent for me to see her with a view to immediate operation. I did not think that she had acute appendicitis, and decided to keep her under observation. The next day I found that her abdomen was distended and that at intervals she complained of griping pain. The sister of the ward informed me that she got practically no result from the

enemata Her temperature was subnormal On the next day, April 16 she looked very pinched and anemic On examination her abdomen was distended, at one time it felt doughy and at other times hard and rigid Her temperature was 99° pulse 90 and I was informed that she had vomited a round worm and passed one per anum In the left hypochondrium I thought I could feel a mass I then made the diagnosis of obstruction with round worms and operated at once The abdomen was opened with a median abdominal incision below the umbilicus The ileum was inflamed and collapsed In the left upper part of the abdomen I felt a mass, and on pulling it out

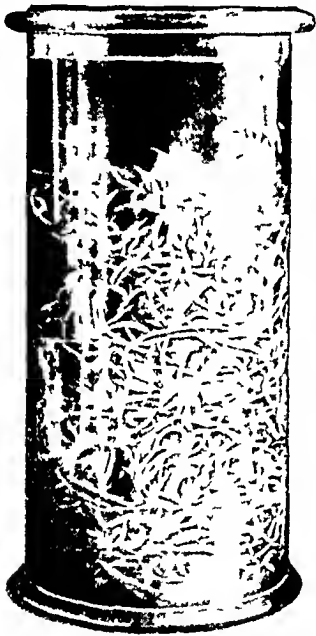


FIG 262—Case 1 899
Ascaris lumbricoides



FIG 263—Case 4 Re-
sected portion of jejunum
containing 268 *Ascaris lum-*
bricoides

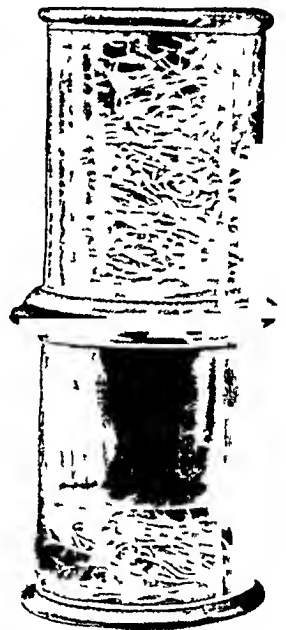


FIG 264—Case 3 Upper
jar, 697 female *Ascaris lum-*
bricoides Lower jar, 293
male *Ascaris lumbricoides*

found it to be the jejunum packed tightly with round worms for about 18 in This part of the intestine was very much distended I made a longitudinal incision in the intestine over the worms, and, with the assistance of the house surgeon, proceeded with the unpleasant performance of milking out the worms the majority of which were alive I found it impossible to milk them all out through the one incision, and made another about the same length—3 in—a little lower down, and milked out as many as I could through this incision In all I secured 737 worms As the child was beginning to show evidence of collapse I sutured the two incisions in the bowel with a double row of catgut sutures, left a rubber drainage tube in the peritoneal cavity,

and closed the abdomen. As I felt sure that all the worms had not been secured, I subsequently treated the child with salutarin and recovered 253 more by this means. I took the worms found at the operation to Dr. Annie Porter, and also had those that were recovered afterwards sent to her. The total number of worms obtained from this child was 990 (Fig 264). Dr. Annie Porter's report follows: Although the child did not develop general peritonitis which I dreaded she might, there was a little superficial sepsis in the wound where the tube had been. She however made an uneventful recovery and was discharged from the hospital on May 22, 1923. She went to the Hospital Convalescent Home and after a month had put on weight, developed rosy cheeks and looked a very happy, healthy child.

Case 4—A European girl, age 10 years, was admitted to the General Hospital on May 21, 1923, from the same orphanage as Cases 2 and 3, with a diagnosis of acute appendicitis. Her temperature was 100.8°, her pulse 135, and she looked intensely ill. The abdomen was distended and in the epigastrium Dr. Dauth thought he could feel a mass which was dull on percussion. The child complained of acute pain in the abdomen and the history was obtained that she had been ill for four days and that her bowels had not moved during that time. The abdomen was opened by Dr. Dauth through a right rectus incision and immediately gas escaped through the aperture. He found a milky fluid free in the peritoneal cavity. The incision was extended in an upward direction and a portion of the jejunum was found to be gangrenous and perforated in three or four places (presumably by the worms). About two feet of bowel, including the gangrenous portion, was resected. This portion was tightly packed with round worms (Fig 265)—some of the worms have dropped out of the bowel and are seen at the bottom of the jar. In addition, "hundreds of round worms were evacuated from a portion of the jejunum lower down, adjacent to the gangrenous portion, through a longitudinal incision in the bowel. Subsequently 268 worms were removed from the resected portion of the bowel. All the worms which had been evacuated from the portion of the jejunum lower down were put into a bucket and unfortunately thrown away and therefore could not be counted. Dr. Dauth, however, stated that there were 'hundreds of worms.' The abdomen was closed without drainage, and the child died the same night.

For the sake of convenience the salient points of the cases are tabulated. It will be noticed in the histories that there are certain points of similarity in the four cases: (1) All came from institutions and not from private homes, (2) All gave a very short history, although they had presumably been infected for quite a long time, (3) All were about the same age, (4) The majority (three) were females, (5) The majority (three) came into hospital with the diagnosis of acute appendicitis, (6) In all, the jejunum was the portion of the gut in which the worms were impacted.

As stated above, the literature at my disposal is very meagre, but I find recorded in the *Journal of the American Medical Association*, 1923, Jan. 20, a case of intestinal obstruction due to nine round worms, in which a resection had to be done by Dr. Baugh, of Albany, also in the *Journal of Tropical Medicine and Hygiene*, 1922, July 1, a case is recorded by Dr. Ingram which is of great medico-legal and surgical interest. In this case he found twelve

round worms in the bowel and a perforation of the bowel, probably caused by a worm pushing its way through a weakened part of the wall of the gut. In the resume of current literature in the *Journal of the American Medical Association*, 1921 Feb. 12, reference is made to two cases by Gilberti in both the bowel had been perforated by round worms. In the one case two worms were found and in the other three. The one was successfully operated on and the other case ended fatally. In the 1921-1922 and 1923 *Quarterly Cumulative Index to Current Medical Literature* published by the American Medical Association, there are a few other references to cases of obstruction with round worms but as the journals quoted are not available, I cannot give the details of the cases.

TABLE SHOWING DETAILS OF FIVE CASES

	CASE 1	CASE 2	CASE 3	CASE 4
Age and sex	11 Male	9, 1 cm. male	8, Female	10, 1 cm. male
Race	Hottentot	European	European	European
Residence	Reformatory	Orphanage	Orphanage	Orphanage
Time ill	3 days	2 days	4 days	4 days
Provisional diagnosis	Intestinal obstruction	Acute appendicitis	Acute appendicitis	Acute appendicitis
Condition found at operation	Intestinal obstruction	Intestinal obstruction	Intestinal obstruction	Intestinal obstruction and perforation Gingrene of bowel
Portion of intestine involved	Jejunum	Jejunum	Jejunum	Jejunum
Number of worms recovered at operation	851	"Several hundreds"	737	268 + "hundreds" thrown away
Number of worms recovered subsequently	18	7	253	None
Proportion of male to female worms	1 : 6	Unknown	3 : 7	5 : 12
Average length of worms	Males 5 in., females 6½ in.	Unknown	3½ in.	5 in.
Result of operation	Cure	Death	Cure	Death

II PARASITOLOGICAL NOTES (A. PORTER)

Ascaris lumbricoides, the large round-worm of man, is a common parasite both of Europeans and of natives in South Africa. The infestation is often relatively slight, but on occasions I have obtained fifty to sixty worms at post-mortem examinations of human intestines. Larger numbers have been rare. It is known that among round-worms there is often predominance of one sex over the other, and Brumpt (1921) has shown experimentally that, in the case of *Strongyloides papillosus* in sheep, 2000 females develop to 1 male worm. If the infection is produced in rabbits, the proportion alters greatly, the ratio of females to males being 409 to 237. Whether the proportion of

female to male ascarides varies in Europeans and natives remains as yet uncertain, and more cases need investigation. There are, however, indications that such differences may occur.

The cases of massive infestation with ascarides that are discussed here came under the notice of my co-author Dr. Joseph I. Levin. In two of them all worms removed at operation and also those passed subsequently came into my possession. In one case a length of gangrenous intestine, greatly distended by densely packed ascarides, was available but the greater part were destroyed in hospital. Of the remaining case I regret that no material came to me.

The parasitology of the three cases may now be given —

Case 1 —The worms received immediately after the operation on the young Hottentot boy numbered 851. Subsequently 18 more worms were received, having been recovered from the boy per os and per anum. There may have been even more worms, for fragments were received on several occasions that were incapable of reconstruction into complete worms, some having been semi-masticated. Of the 869 worms (*Fig. 262, Case 1*), the larger number were females and the proportion was approximately 1 male to 6 females, the actual numbers being 128 males and 771 females. The worms were relatively long, the average length of the females being $6\frac{1}{2}$ in. and of the males 5 in.

Case 2 —In this instance unfortunately the worms evacuated at operation were not preserved.

Case 3 was an even more massive infestation than that of the Hottentot boy. The little European girl was aged 8. Immediately after the operation the mass of worms was brought to me by Dr. Levin. I sorted and counted them. There were 737 in all made up of 222 male and 515 female *Ascaris lumbricoides*. All worms passed by the child after operation were put into formalin and sent to me. Eleven days after the operation I received a set of worms consisting of 16 male and 78 female ascarides. Treatment with a vermifuge was commenced, and five days later a consignment found to consist of 55 male and 101 female ascarides was received. This was the last large number of worms, but after an interval of twenty-one days 3 macerated female ascarides reached my laboratory. Since then no more worms have been passed, though the child has been under observation for more than a month. The total number of worms received was 990 (*Fig. 264, Case 3*). The proportion of the sexes is roughly 3 males to 7 females, the actual numbers being 293 males and 697 females. The average length of the worms was $3\frac{1}{2}$ in.

Case 4 —The patient was a European girl, age 10. Most unfortunately only the portion of gangrenous intestine removed at operation and a very few of the worms were available, some 'hundreds' removed at operation having been destroyed. The portion of jejunum with some of the worms that had dropped out was photographed (*Fig. 263, Case 4*). It was then opened and 268 ascarides were removed. Of these 188 were females and 80 males. The proportion of male to female worms was thus roughly 5 to 12. Had all the worms removed at operation been available, the proportion of the sexes would probably have been different, judging from the variations found in the successive batches of worms obtained from *Case 3*. The size of the worms was also larger than those in *Case 3*, the average length being $5\frac{1}{2}$ in.

From the three cases examined it is evident that there is a marked difference in the numbers of male and female ascarides found. Examination of my post-mortem records shows that similar differences in the numbers of male and female worms are usual though in none of these records have such large numbers of worms been noted nor were any of them cases of intestinal obstruction.

There is also a difference between the proportion of male to female ascarides as found in a native and a European case. Whether such may be due to differences between the native and European intestine cannot be stated until many more cases have been examined, but the conditions observed seem to suggest that the milieu of the native intestine is less favourable to the male ascaris than that of the European intestine the converse being the case for the female worm.

There is some interest attaching to the fact that all three European children were inmates of the same orphanage. Two of these three cases occurred within a month of each other. The ease and speed with which round-worm infestations spread among inmates of institutions is no new thing.

In connection with infestation by *Ascaris lumbricoides* it may be of service to summarize the life-history of the worm so ably worked out by Major F. H. Stewart, I.M.S., published during the period 1916-18 and since confirmed by a number of workers. Until recently it was believed that an invertebrate host was necessary for *Ascaris*. Such is not the case infection occurring by direct ingestion of ova. Ripe ova have been found to give better results in experimental animals than freshly shed ones. The larvae as at first they cannot resist the action of the digestive juices. The larvae are fragile but they bore through the mucosa and reach the liver by way of the blood-stream. From the liver they migrate to the lungs where they remain about eight days. They then begin to pass into the intestine and on about the ninth day some begin to migrate back to the lungs though others persist in the lungs for as long as fifteen days. By the tenth day migration via the oesophagus or the mouth towards the stomach is attended established and the larvae pass rapidly through the lungs as attended by bronchitic symptoms. The passage of the larvae through the lungs is well as to other causes. Stewart states that there is 'reason for supposing that a great deal of the debility of the natives of the tropics is due to ascariasis and that this disease is at least equal to ankylostomiasis in economic importance. Its rôle in intestinal obstruction is well shown in the present series of cases.

In Johannesburg I have been able to confirm Stewart's work in all essential points. There are slight differences in the times necessary for development of ova and larvae but this is considered to be due to climatic differences. Johannesburg being far inland and at an altitude of nearly 6,000 feet while Stewart's experiments were carried out in Hong-Kong at sea level.

ASEPTIC INTESTINAL ANASTOMOSIS : WITH SPECIAL REFERENCE TO COLECTOMY.

BY JOHN FRASER AND NORMAN M. DOTT, EDINBURGH

It is a somewhat suggestive fact that it is difficult to obtain any large amount of statistical evidence regarding the results of, and the mortality associated with, the operation of colectomy. The explanation probably is that the majority of us are disappointed with the results we obtain, and it is but natural that indifferent results are rarely published. Under any circumstances the operation of enterectomy is a grave one, removal of a portion of the large intestine is a more serious procedure than a corresponding operation on the small intestine and it is instructive to notice that colectomy of the distal portion of the large intestine is a more dangerous operation than a corresponding removal of the proximal segment.

The Evolution of the Operation—Evidence of the difficulties which surround the operation is suggested by the variety of methods which have been put forward from time to time, they may, in fact, be divided into epochs in the evolution of the operative treatment. With the advent of what we may term 'modern surgery' enterectomy was attempted by axial anastomosis with sutures, but the results were so disappointing that an attempt was made to improve them by the use of various mechanical contrivances, the best known of which is probably Murphy's button. The disadvantages of such appliances soon became obvious, and there was a return to suture anastomosis—lateral anastomosis, however, being substituted for the axial union. The results were improved by this departure, and, as far as colectomy was concerned, union by lateral anastomosis remained the procedure of choice until within the last ten or fifteen years. During this period there has been a return to the axial union by suture, but the safety of the suture line has been more fully guaranteed by the previous institution of a cæcostomy or a colostomy.

The want of stability implied by such a variety of methods would seem to indicate dissatisfaction with results, and therefore it is interesting to recall a summary of the operative statistics which are available.

Statistics—The paper which Paul¹ of Liverpool, published in 1895 may be said to have been a landmark in the progress of colectomy. He was the first to advocate the two-stage operation, and he published records of 14 cases with only a single fatality and that was an instance in which the rule was broken and the complete operation carried through in one stage. Paul in his paper emphasized the danger of the one-stage operation, and in 1903 Mikulicz² issued an interesting report bringing out the contrast between the results of the one-stage and the two-stage operation. The first showed a mortality of 42.9 per cent, the second a mortality of 12.5 per cent. In this

county Pollard,³ Littlewood,⁴ and Mayo Robson⁵ in the years 1903 and 1904 recorded various groups of colectomies, all of which were performed by the two-stage method, and, except in Pollard's series, where there were 7 cases without a death, the average mortality was from 7 to 10 per cent.

These various figures are too small, however, to afford any trustworthy statistical information, because specially favourable conditions might conceivably establish good results. In 1907 Hartmann⁶ collected 143 cases of enterectomy (colectomy) for malignant disease, with a mortality of 33.5 per cent, and in the same year Ansehut,⁷ working in Mikulicz's clinic, collected 139 one-stage operations from the literature with a mortality of 46 per cent, and as a contrast he collected a number of the two-stage operations with a mortality of 18 per cent. Finkelstein's figures, as quoted by Oppel,⁸ are 29 and 16 per cent respectively, Mayo,⁹ using the two-stage method, recorded 184 cases, with a mortality of 17 per cent. A number of other collections of statistics exist, but most of them correspond to the figures quoted above, and the position may be summarized by saying that the operation of colectomy as a single-stage operation is associated with a mortality of about 30 per cent, and in the two-stage operation with a mortality of about 10 per cent. The results of the temporary caecostomy method are about the same as those of the two-stage operation.

These figures indicate an unsatisfactory position. The statistics represent the results of picked cases—cases, in other words, which have been suitable for operation—and therefore the best of the mortality figures is uncomfortably high.

The Difficulties and Dangers of the Operation—It is not difficult to see the explanation of the dangers which surround the operation. Peculiarities of blood-supply, and the highly septic contents of the large intestine, coupled with their solid nature, are the factors which render surgery of the colon so dangerous. The blood-supply and sepsis are closely interrelated, and the influence of either must be very strongly reflected on the other. Of all the various factors, however, sepsis is the most serious. When we consider the highly infective content of the large intestine and the soiling which must inevitably occur in the ordinary 'open' methods of colectomy, it is wonderful that the results are as good as they are. It is no exaggeration to say that when the ordinary open operation is performed, the individual operated on must overcome a local peritonitis before his recovery is assured. In fact, the element which gives the operation its serious character and its associated high mortality is essentially one of infection, and the abolition of this factor may well revolutionize the operation results. The existence of organisms within the bowel is a physiological condition which cannot be prevented, in the presence of obstructive lesions the intensity of the intestinal flora is accentuated, and there is probably an associated increase in the incidence of such actively pathogenic organisms as the streptococci.

But, coupled with the existent potential sepsis, there are questions of blood-supply and of structural peculiarity which increase the dangers. The former may be said to be arranged on a somewhat sparse plan, the arteries supplying the colon pass round the bowel in a circular direction from the mesenteric border and are parallel to each other. There is very little

anastomosis between the different vessels in the wall of the colon, and though there is a comparatively free anastomosis at the mesenteric attachment the free edges of the bowel are by contrast very scantily supplied with blood. A profuse and active blood-supply is one of the best safeguards against the development of sepsis, and therefore the comparative sparsity of the colon supply is a factor which must be taken into consideration—the combination of sepsis with the small blood-supply must exert an unfortunate effect upon the healing process after colectomy.

A second factor of great practical importance is the presence of subperitoneal deposits of fat on the colon wall. In stout subjects the fat may so completely envelop the colon that it will be difficult to find any extent of uncovered serous surface, and its presence may give rise to serious difficulties in accurate approximation and efficient suturing. Hence the further risk that in the presence of even a minor degree of sepsis the fat quickly necroses and sloughs.

Lastly it is important to remember that in certain situations the relationship of the peritoneum to the colon wall is such that portions of the bowel are uncovered with peritoneum and so come into contact with the retroperitoneal connective tissue. There is thus a space of high absorption possibilities, it is profusely supplied with lymphatics, and infection, once introduced into the area, may make rapid progress to a fatal termination. In such dangerous situations the mortality of colectomy is increased by the occurrence of the highly fatal retrocolic cellulitis. In fact, as we have already said, it is the occurrence of sepsis which makes this operation of colectomy such a fatal one, and if this danger is overcome the procedure will lose much of its present risk.

This paper is actually an account of an attempt which we have made to overcome the dangers and to minimize the difficulties of enterectomy in general and of colectomy in particular. It is obvious that an efficient sterilization of the interior of the bowel is impossible, and therefore the only way in which to avoid infection is to prevent any direct opening of the bowel lumen while the operation is in progress. We believe we have achieved this ideal in the method we describe.

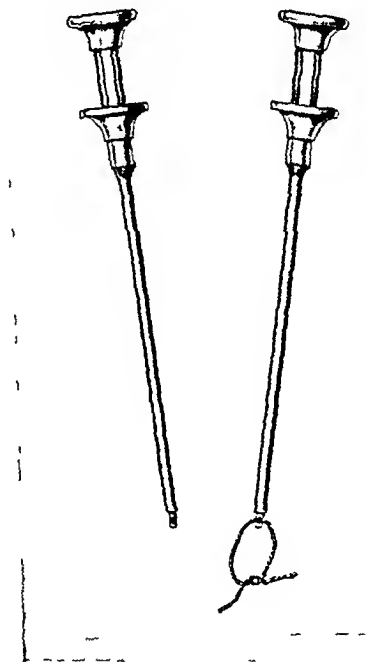


FIG 265.—*Ligature guillotines.* The instruments measure 6 cm in length, and the tubular sheath is 2 mm in thickness. Projecting from its end is seen the solid, centre wire, with an eye in its extremity. The flanges, which constitute the handle of the instrument, are arranged like the automatic release of a camera, so that the central wire can be drawn into the sheath. One instrument is represented with a ligature threaded in place. It will be seen that when the flanges are pressed together, the ligature is cut against the end of the tubular sheath; moreover the guillotine cannot be released from the ligature until the latter is completely severed.

DESCRIPTION OF THE METHOD AS USED IN AXIAL ANASTOMOSIS

We at first contemplated attempting aseptic anastomosis by securing the stumps of gut in the grasp of snares, inserting a circular suture, cutting through and releasing the stumps by means of the snares, and withdrawing the latter through the suture line, but the technical difficulties appeared considerable, the asepsis to be anticipated doubtful, and we noted that Burket had tried a similar method and found it imperfect. It then occurred to us that, if the stumps were closed by means of ligatures and the ligatures were severed by means of snares after anastomosis of the stumps, the difficulties would be overcome. In this way very fine snares or guillotines may be employed, and, as they touch only the peritoneal surface of the bowel, they carry with them no risk of contamination as they are withdrawn through the suture line. After successful experimental trials, carried out in the

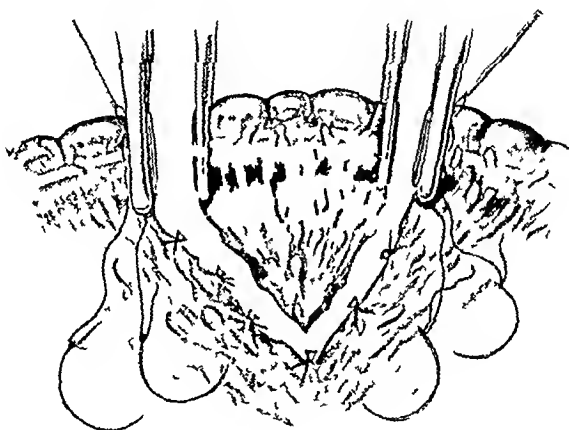


FIG 266—*Resection*. The segment of gut to be excised has been isolated with a wedge shaped portion of mesentery attached. The gut has been divided between the pressure forceps and crushing clamps and is about to be removed. The insertion of the purse string sutures for closing the stumps is shown, and the position of the ligature guillotines upon them is indicated.

Department of Physiology, Edinburgh University, by kind permission of Professor Sir E. Sharpey Schafer we have applied the method to clinical cases of carcinomatous obstruction of the colon. The gratifying results obtained appear to us to warrant a detailed report of the method.

Resection and Reconstruction—The only special instruments required are the two ligature guillotines (Fig 265), the usual crushing clamps* are employed, but controlling clamps are dispensed with.

1 *Resection* (Fig 266)—The resection is carried out in the usual manner. The mesentery and lymphatic fields are mobilized as may be necessary, the segment of bowel to be removed is secured at each end by pressure forceps, the mesentery is perforated at these points and it is secured and cut so that

* Pairs model is very convenient for the purpose.

a wedge-shaped portion is removed. Strong crushing clamps are applied to the gut close to the two pressure forceps, and the gut is divided between them at each end. The segment of bowel enclosed between the pressure forceps with its attached mesentery and lymphatic field, is removed immediately *en bloc*. The division may be made either by the electric cautery or by the knife, in the latter case the section is carried flush with the clamp, and the cut edge touched with liquid carbolic acid. The vessels of the resected mesentery may now be tied off.

2 *Preparation of the 'Blind Ends'* (Fig. 267).—The ends of the gut are now to be ligatured, and it is safer to employ a purse-string suture for the purpose in order to obviate the risk of its slipping. The ligature guillotine is threaded upon, and placed about the middle of, a strand of strong catgut and each end of the latter is armed with a needle. The suture is inserted close to the edge of the crushing clamp. Commencing with one needle at

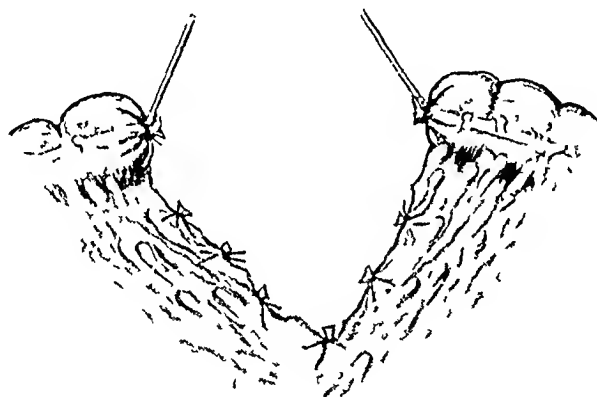


FIG. 267.—*Preparation of blind aseptic ends.* The crushing clamps have been removed and the ligatures tightened and tied off. Note the small stumps of crushed tissue which project from the centre of the blind ends of the bowel, and the position of the ligature guillotines upon the controlling ligatures.

the antimesenteric border of the bowel, a few points of seromuscular suture are taken up to terminate at the mesenteric attachment. With the other needle the procedure is repeated on the other half of the circumference. Thus, when the ligature is tightened, the guillotine remains attached to the antimesenteric border, while the knot is at the mesenteric attachment. As the clamp is released the ligature is drawn tight and tied as above. The end of the bowel is converted into a 'blind end', with a minute stump of thoroughly crushed tissue projecting at its centre (Fig. 267). Although the crushed tissue contains no mucous membrane, we have taken the precaution of making a further application of the cautery or of liquid carbolic acid to it to ensure asepticity. The ease with which the stump can be invaginated into the end of the bowel should be tested, that there may be no tension on the anastomosing sutures. If necessary the mesentery should be further divided, to permit of easy inversion. It will be noted that the ends of the bowel have

been prepared for anastomosis without at any time exposing the mucous membrane. They are aseptic and securely closed, so that they can be freely handled without apprehension of contamination.

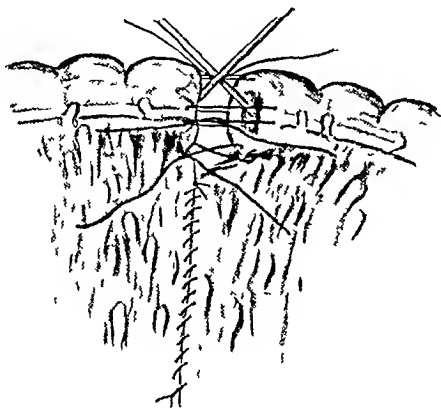


FIG. 268—*Anastomosis*. The gap in the mesentery has been closed. The interrupted mattress sutures have been inserted but not tied (In practice each is tied as it is inserted.) Note particularly the crossed mattress suture controlling the area of mesenteric attachment and the slight inversion of the stumps which permits approximation of the circumference when the stitches are tied.

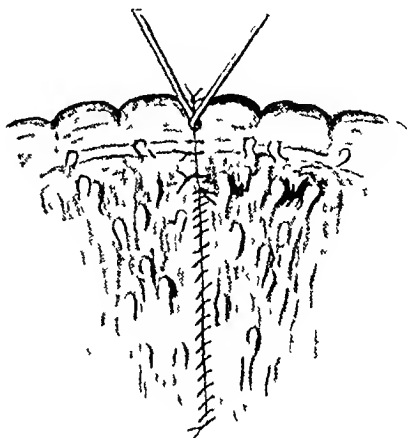


FIG. 269—*Anastomosis*. The mattress stitches have been tied and the ends of the bowel thereby approximated. This constitutes the first line of suturing. The ligature guillotines are seen projecting through the suture line at the antimesenteric border.

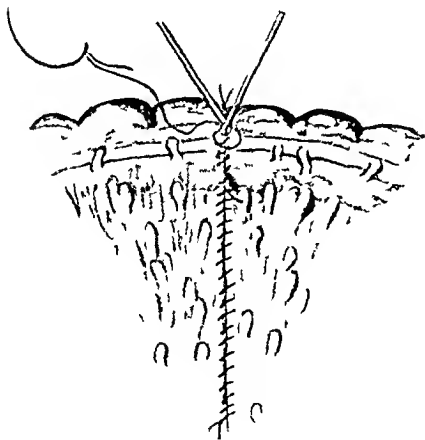


FIG. 270—*Anastomosis*. The continuous circular suture has been inserted commencing at the antimesenteric border on the distant side of the guillotines. It has passed round, traversed the mesentery and terminated in a loose stitch over the point of emergence of the guillotines.

3 Reconstruction of Continuity—It is convenient to close the gap in the mesentery in the first place, and the guillotines attached to the ends of the bowel, employed as tractors greatly facilitate this procedure. The mesenteric borders of the ends of the bowel are approximated by a mattress suture, and three or four interrupted stitches uniting the remainder of their circumferences form the first line of union (Figs 268, 269). The stitches of tanned catgut should penetrate to the submucous coat. As they are tightened the stumps are allowed to invert slightly into the ends of the bowel. The ends form a double diaphragm across the lumen. The thin guillotines are allowed to project together through the suture-line at the antimesenteric border. If the field of operation is difficult of access it is well to pay special

attention to the area of mesenteric attachment, inserting two or more superimposed mattress stitches before the remainder of the circumference is united.

By this precaution easy access to this 'danger point' and its secure closure are ensured in the most difficult case. A circular Lembert suture of fine tanned catgut is carried round the circumference of the anastomosis. Commencing at one side of the guillotines on the antimesenteric border, it passes round to the mesenteric attachment, the needle is passed through the mesenteric eye-fist, and the suture continued to reach the antimesenteric border again. It is completed by taking a loose stitch over the guillotines (*Fig 270*). The original ligatures on the stumps are now cut by means of the guillotines and the latter are withdrawn. The loose stitch is tightened and tied off so closing the point of exit of the instruments (*Fig 271*). In this way the stumps are released and intestinal continuity is re-established (*Fig 272*). In dealing with the human colon we have thought it wise to superimpose a second continuous encircled suture of linen thread. (We now have reason to believe that tanned catgut is preferable *see below*). We may mention, however, that the approximating and single encircled catgut sutures were relied on in experimental work and found entirely satisfactory. The adequate zone of complete peritoneal apposition between the two lines of stitches (*Fig 272*) should be particularly noted.

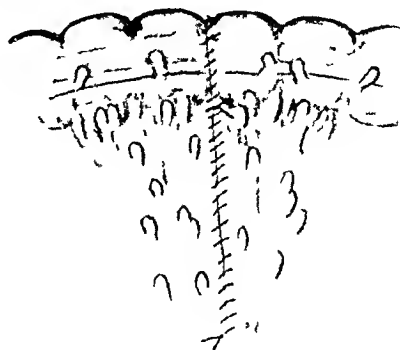


FIG 271—*Anastomosis* The internal controlling ligatures have been cut by the guillotines and the latter withdrawn. The loose stitch has been tightened and tied off so closing their point of exit. Anastomosis is complete—intestinal continuity is re-established. A further circular suture may be inserted (*see text*).

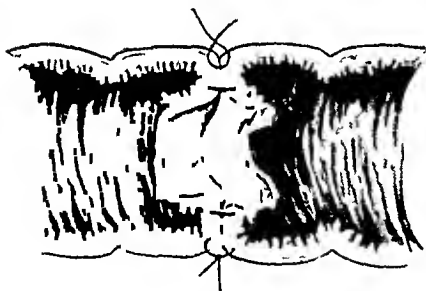


FIG 272—*Sectional view of completed anastomosis* The diagram shows the area of complete apposition between the inner row of interrupted sutures and the outer circular row. This area can be increased as desired by insertion of an additional line of circular sutures. The intubed cuffs of bowel with crushed edges are shown. It will be readily appreciated that the whole structure being soft and mobile the cuffs of bowel are opened out in the direction of intestinal flow, so as to give an ample lumen. Experience has shown that these cuffs entirely disappear.

In this way the resection and anastomosis can be carried out rapidly and aseptically, and they can be performed in situations which would preclude the use of controlling clamps, and in which the ordinary methods of suture would be extremely difficult or impossible. Although the description is necessarily somewhat intricate, the resection and reconstruction can be completed easily within fifteen minutes in a straightforward case.

TECHNIQUE OF END-TO-SIDE ANASTOMOSIS BY ASEPTIC METHOD—End-to-side ileocolostomy may be selected for descriptive purposes. The ileum is

divided between a pressure forceps and crushing clamp, the crushing instrument being applied to the upper segment. The lower segment is closed by

purse-string suture and invaginated as usual. The upper segment is prepared as a blind aseptic end with ligature guillotine attached, as described for axial anastomosis. From the antimesenteric aspect of the wall of the colon a little cone is drawn out with forceps, the crushing clamp is applied to the base of the cone, and the apex is cut off with knife or cautery. A sufficient amount should be clamped and removed to obviate the risk of missing a loose and folded mucous membrane. Inspection of the cap of tissue removed will reflect the size of the opening which has been made, by the island of mucous membrane on its inner surface. The cut edge in the grasp of the clamp is disinfected as described above and the purse-string suture with ligature guillotine threaded is inserted close to the clamp. The subsequent steps are exactly as in axial anastomosis, in short, after picking up the cone and cutting off and ligaturing its apex, the stump is treated as if it were an 'end stump'.

The operation has proved very satisfactory experimentally. As the internal ligatures are severed in the last stage of the procedure, one observes the junction expanding as the lateral opening in the colon springs open. We have not yet had occasion to apply this method in human surgery.

EXPERIMENTAL STUDY

It was, of course, essential to conduct a thorough experimental test of our method of intestinal anastomosis before applying it to the human subject, and a brief account of the experiments and their results may be of interest. The experimental animal selected was the dog, as it is the available animal whose intestinal tract most closely resembles that of man. The chief points



FIG 273—Dog 8/23 Specimen of axial anastomosis of transverse to pelvic colon removed 36 hours after operation (fixed in formal)

A External appearances Note the smooth, completely healed suture line. The slight expansion of the bowel at the junction is due to greater fixation shrinkage of the gut above and below it.

B Internal appearances Note the intuned cuffs whose crushed edges have already sloughed off. There is an adequate lumen and the soft projecting cuffs are easily folded aside by intestinal contents.

which required investigation were the possibility that the intuned cuffs might cause intestinal obstruction, the possibility of uncontrollable hæmorrhage from the free edges of the cuffs, the possibilities of late complications such as stenosis or polypoid formations, should the intuned cuffs persist as projections into the lumen of the bowel, the comparative merits of our method as compared with others as regards facility and rapidity of conduct

ASEPTIC INTESTINAL ANASTOMOSIS

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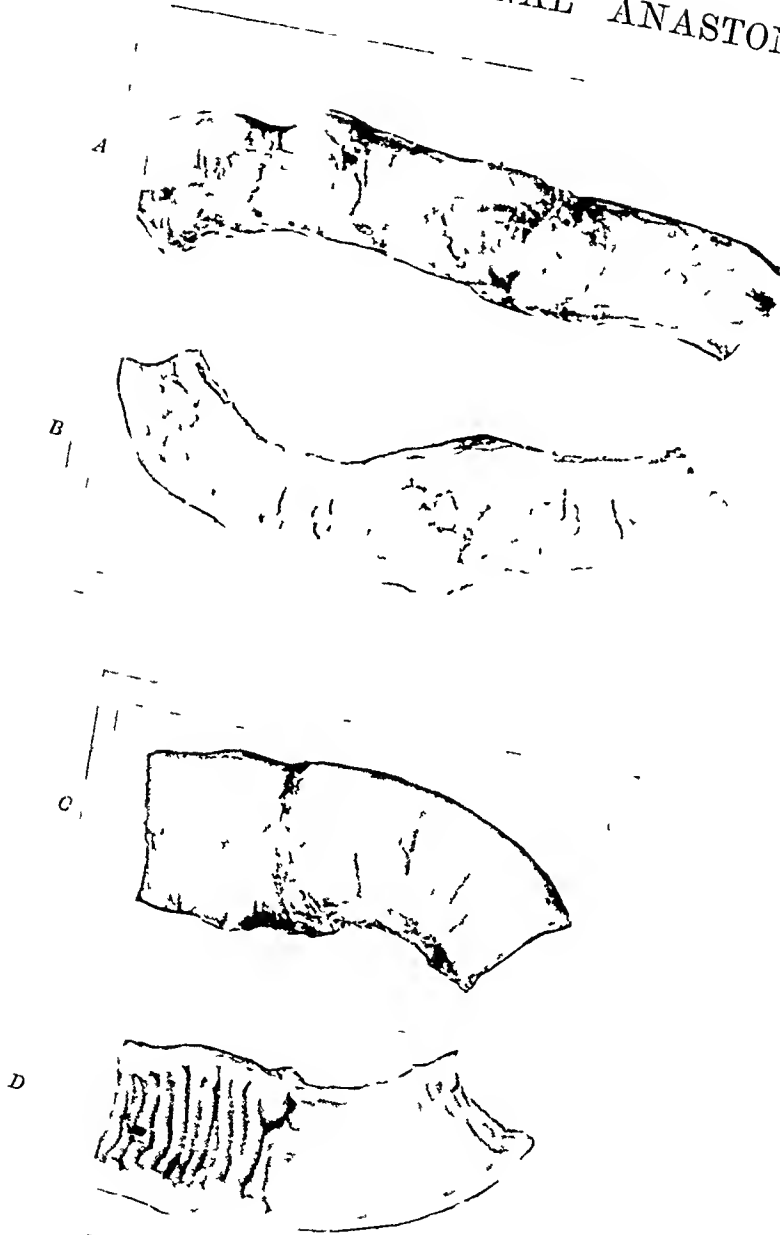


Fig 274—Dog 6/23 Specimens of arial anastomosis of small and of large intestine after double resection removed 73 days after operation (fixed in formel)

A, Small intestine—jejunum external appearances The suture line is barely recognizable

B Small intestine internal appearances The outline of the mucosal surface

C, Large intestine—transverse colon to rectum external appearances The outline of the bowel is quite smooth The line of anastomosis is recognizable as a shallow circular depression

D Large intestine internal appearances The line of anastomosis is not visible The junction of the comparatively smooth walled transverse colon with the rugose rectum is, however, very obvious

It should be noted that the conditions of the experimental test were more stringent than those of clinical practice for the following reasons: the intestinal wall of the dog is much thicker than that of man in proportion to the calibre of the lumen, and obstructive complications were therefore more to be feared, the greater relative thickness of the wall of the canine intestine is dependent on its plain muscular tissue, and this tissue, being comparatively inflexible, intuming without undue tension is more difficult of accomplishment, and, owing to the greater preponderance of pure muscular tissue, as contrasted with the fibrous element sutures have a less secure hold. Thus,

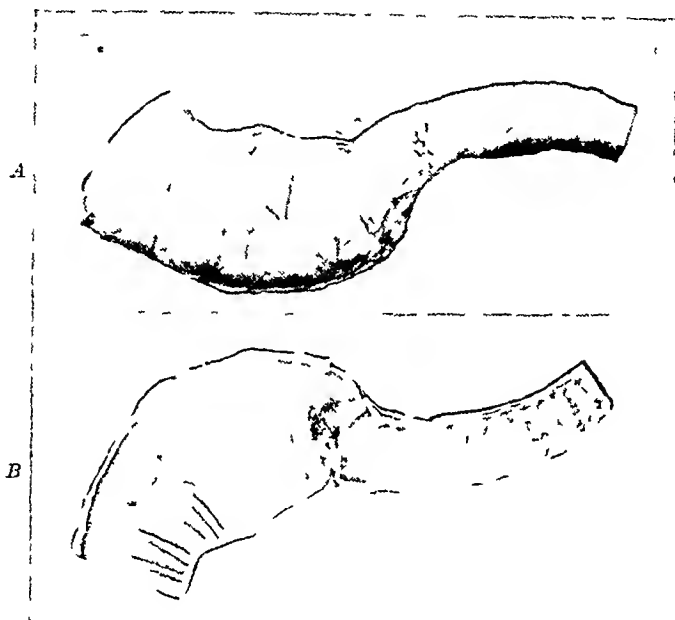


FIG. 275.—Dog 5/23. Specimen of axial anastomosis of ileum to transverse colon following right hemicolectomy removed 70 days after operation.

A External appearances. The suture line is unrecognizable and the ileum passes smoothly into the colon.

B Internal appearances. In this case the turn has not entirely disappeared, but projects valve like into the colon. In the fresh specimen we were able to demonstrate that it acted as a very competent ileocecal valve allowing a perfectly free stream in the normal direction and almost completely obstructing flow in the opposite direction. It is possible that its persistence in this case may have had some relation to this normal valvular function.

having satisfied ourselves regarding the possible difficulties by experiment on the dog we feel that we can recommend the method with considerable confidence as a reliable and practical surgical procedure. Our experience in its clinical application entirely supports this opinion.

The following operations were performed on dogs some of which were adult animals and some young puppies: (1) Four segmental colectomies, completed by axial reconstruction. In two of these a segment at the splenic flexure was removed, in two the entire pelvic colon was resected. (2) Two right hemicolectomies in which continuity of the intestines was re-established

by arial anastomosis of the ileum to the transverse colon (3) Two short-encuring operations by end-to-side ileosigmoidostomy (4) In one case (a puppy of 2½ months), segmental resection of the jejunum and left hemicolectomy were performed at one sitting, both excisions being followed by arial anastomoses These operations were very well tolerated Most of the animals took a good fluid meal within two to four hours of the operation and within twenty-four hours they would play with their companions, showing no evidence of discomfort Post-operative vomiting occurred in only two instances, and in them it was limited to the first twenty-four hours Thus temporary obstruction—even in the presence of a double resection—was excluded as a possible danger A trace of dark blood was always present in

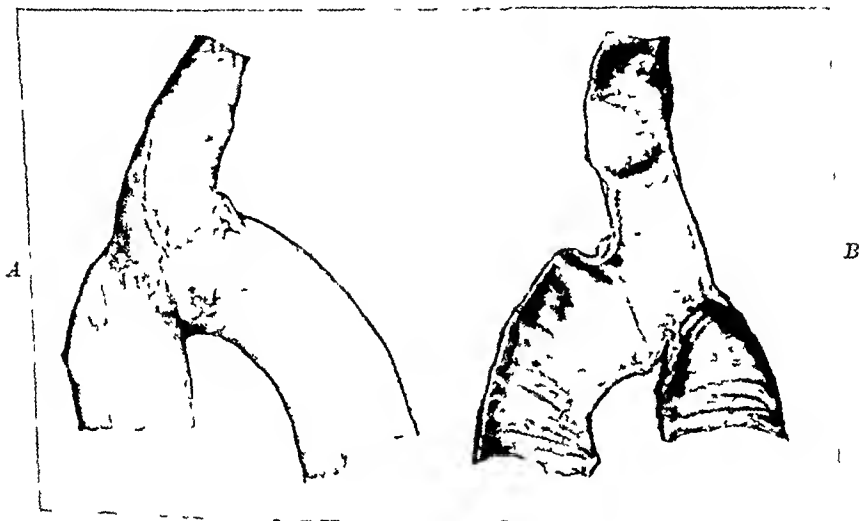


FIG 276—Dog 2/23 Specimen of end to side ileosigmoidostomy, removed 78 days after operation

A, External appearances The suture line is only marked by the conformation of the junction of the intestines The ileum is seen to enter the convexity of the sigmoid loop at a right angle The junction is smooth, and shows no constriction or angulation

B, Internal appearances The different textures of the ileal and colonic mucous membranes is the only indication of their site of junction Note the wide free lumen between the ileum and the lower functional limb of the colonic loop The constriction at the mouth of the upper limb of the loop is more apparent than real and is due to fixation in a folded position

the first motion after operation, which was usually passed on the second or third day, and traces were occasionally noted for three or four days subsequently The melenæ was not greater in amount than that which follows any method of intestinal anastomosis The motility of the intestine was, of course temporarily deranged by the operative manipulations, as evidenced by one or two days' constipation It did not persist beyond this period, after which in all cases the bowels acted quite normally The examination of specimens of the various types of anastomosis mentioned above demonstrated that within a maximum of seventy days the intuned cuffs of bowel were so completely absorbed as to project no further into the lumen than the normal mucosal folds Thus late complications in connection with the intuned

cuffs need not be considered as a menace to the success of the operation. The crushed edges slough off into the interior of the bowel within the first twenty-four hours (*Fig 273*). A temporary ulcer is present for some time during the healing process at the apex of the inturned fold (*Fig 277*), it is certainly healed by the thirtieth day—probably much earlier but we have not as yet followed out the intermediate stages of healing. Reduction in size of the infolded mass is effected at first by sloughing and to a slight extent by ulceration. Its continued reduction after healing of the ulcer is due to natural atrophy and absorption occurring in a functionless tissue.

Microscopical examination of the line of suture seventy to eighty days after operation reveals the extraordinary powers of adaptation and reconstruction which the tissues of the bowel possess. At this time the place of junction of the mucous membrane cannot be identified, so perfect is its regeneration (*Figs 278, 279, 280, 281*). The junction of the muscularis mucosæ is slightly less advanced, in some cases it is represented by loose



FIG 277.—Dog 8/23. Axial anastomosis of the colon after resection of segment at splenic flexure. Microphotograph ($\times 7$) of suture line 36 hours after operation. The crushed edges have sloughed off. A narrow, temporary ulcer exists at the apex of the inturned mass. The wide area of peritoneal apposition already firmly sealed by fibrin is seen.

submucous tissue only (*Figs 278, 279, 280*), while in others small, newly-formed muscle fibres have bridged the gap (*Fig 281*). The submucous tissue is somewhat thinner and denser in texture than elsewhere, but it has by no means a compact, scar-like structure. The junction of the muscular coats is in all cases evident from the small, angular depression on their outer surface where they had been folded in. The depression is entirely filled by fibrous tissue of loose texture. In all cases at about seventy days (*Figs 278, 279, 280*) the junction is clearly demarcated by the direction of the muscle fibres, which turn inwards at this point. Loose connective tissue binds together their former external surfaces, from which the peritoneal covering has disappeared. At about eighty days a commencing rearrangement of the muscle is evident and many small, newly-formed fibres and bundles are seen permeating the loose connective tissue and re-establishing complete muscular continuity (*Fig 281*). The peritoneal endothelium passes smoothly over the fibrous tissue which fills the depression between the inturned muscular coats.

The most remarkable feature of the suture line is the absence of anything

approaching to dense scar-like fibrous tissue, and the re-establishment of normal anatomy—complete in the mucous membrane and obviously in progress in the outer coats

Some points of general interest emerge from the microscopical examination of the specimens. As already mentioned, only 0000 tanned catgut was



FIG 278—Dog 6/23. Anal anastomosis after enterectomy. Microphotograph ($\times 7$) of suture line 73 days after operation.

The evidence of a mucosal wound has been entirely effaced by reconstructive growth, with the exception of the muscularis mucosae which is not yet reconstituted. The muscular tissue of the intumescence has been almost entirely absorbed and absorption is still in progress. The intumescence is now hardly larger than the normal valvula conniventes. The little angular interval, filled by loose fibrous tissue, still marks the suture line externally. Its surface is covered by peritoneal endothelium.



FIG 279—Dog 6/23. Anal anastomosis of transverse colon to rectum after resection of the intervening segment. Microphotograph ($\times 7$) of suture line 73 days after operation.

As in the previous specimen all traces of the mucosal junction have been effaced by reconstructive processes, with the exception of the muscularis mucosae. The muscular tissue of the intumescence is in process of absorption. The intumescence is now no larger than the normal mucosal folds of the rectum. Externally the angular depression filled by loose fibrous tissue between the infolded muscular surfaces marks the anastomosis. Note the recently epithelialized suture ulcers at the base of the intumescence, due to a too deeply inserted mattress suture

employed for suturing. It is noteworthy that the catgut is recognizable in the muscular and connective tissues seventy to eighty days after operation. It is seen to be in process of slow absorption by phagocytic cells (Figs 280, 281). This gives one considerable confidence in employing it alone for all gastrointestinal suturing, a practice desirable on account of the ultimate absorption of the catgut as contrasted with thread or silk.

It is interesting to note that in the cases of ileocolostomy the mucous membrane of the small intestine within a few millimetres of the junction undergoes a metamorphosis to a colonic type. Its villi are lost, so that its



FIG 280—Dog 5/23 Axial anastomosis of ileum to transverse colon, after right hemicolectomy. Microphotograph ($\times 7$) of the suture line 70 days after operation.

The mucosa is entirely reconstructed and it is with difficulty that the change in mucosal type, from ileal to colonic, is identified. The gap just distal to the site of junction is a wide gland tubule. Note the loss of villi in the ileum adjacent to the colon (the gland cells also show metamorphosis to colonic type). The muscularis mucosae is not yet reconstructed. The intumescence is now less in size than the adjacent, normal mucosal fold. Note the catgut sutures, still evident in the subserous tissue.

surface is plain, and only broken by the mouths of the gland ducts and occasional lymphoid nodes. In the gland tubules the ferment-secreting cells are almost entirely replaced by mucous goblet cells. For this reason, even in



FIG 281—Dog 2/23 End-to-side ileosigmoidostomy. Microphotograph ($\times 7$) of suture line 79 days after operation.

The mucosal junction cannot be identified with accuracy. The mucous membrane of the ileum adjacent to the colon has the characters of large intestine. The villi are lost and the gland cells are of the colonic type. The muscularis mucosae has been reconstructed. The junction of the muscular coats is now hardly recognizable as the direction of their fibres has been rearranged and small fibres and bundles of new formation have permeated the loose cellular tissue of the junction. The site of anastomosis is clearly identified externally by the small angular interval between the returned muscular coats which is filled by loose fibrous tissue. The peritoneal endothelium smoothly crosses the junction. Note the catgut suture in the muscular tissue to the right of the junction line.

ileocolostomies, it is impossible to identify the mucous membrane junction after about eighty days (Fig 281). A slightly more abrupt change of glandular characters is seen in a 73-day specimen (Fig 280). A similar metamorphosis

of ileal to colonic type of mucous membrane has been described in cases of enterostomy (Holmgren¹⁰)

The error of permitting even the inner mattress sutures to penetrate to the mucous membrane is demonstrated by the recent stitch ulcers shown in Fig 279. These ulcers are only just healed seventy-three days after the operation, long after healing of the cut edges of the mucous membrane, where the junction is not recognizable. These minute ulcers gave rise to no obvious ill effects in the case shown but they certainly represent an avoidable imperfection of technique.

Throughout the conduct of these experimental operations we were much impressed with the simplicity of the method and the rapidity with which it could be carried out. The ease and security with which the aseptic ends of the bowel can be manipulated, and the absence of controlling clamps, are especially welcome to the operator when working in a field difficult of access.

THE CLINICAL APPLICATION OF THE METHOD

The encouragement which the experimental work had given us led us to adopt this method of colectomy in two cases of colon tumour, both of which presented considerable dangers and difficulties if operated on by the usual methods.

Case 1—Male, age 56. The case came under our care during an attack of acute intestinal obstruction. This was relieved by a temporary cæcostomy, and a large malignant tumour was localized in the splenic flexure of the colon. Twelve days after the preliminary operation the tumour was removed. Owing to its situation and to its extent, it was impossible to apply clamps in spite of the most complete mobilization of the bowel. The ligature method was employed, and the special facility of its application permitted a very complete removal of the affected segment of bowel—in fact, we remarked at the time of operation that only by the ligature method could complete removal be ensured. The resection was carried out on the lines already described, no difficulties of any consequence were encountered, and the further progress was one of an uneventful recovery.

Case 2—Male, age 65. Subacute obstruction symptoms had developed as the result of a malignant tumour situated at the lower end of the loop of the pelvic colon. The immediate symptoms were relieved by a preliminary cæcostomy and ten days later the tumour was resected by the aseptic ligature method. The case presented certain aspects which in our opinion made it especially suited for the ligature method. The fixation and the situation of the tumour were such that the use of clamps would have been difficult if not impossible. The patient was in a very debilitated condition throughout the course of his illness, and we felt that any superadded degree of infection, however slight, might easily turn the scale to a fatal issue, and the guarantee therefore of the avoidance of sepsis by the ligature method was a great advantage. With a very slight degree of disturbance the complete excision of the tumour was performed.

Possible Criticisms of the Method—It is most likely that the criticisms which the method may arouse will take two lines. The fact that the mucous edges are not separately sutured will be objected to for the alleged reason that this delays the process of healing and at the same time encourages infection to pass into the more superficial regions of the suture line. Our results have consistently shown that there is no real danger on this score.

the healing of the mucous edges is early assured, and within a surprisingly short time their continuity is restored. In fact, the experimental studies have already shown that individual suturing of the mucosa is unnecessary and the operation has been planned upon the recognition of this.

The second criticism will be directed towards the possibility of obstruction developing at the line of anastomosis. It might be imagined that the invaginated cuff of bowel would give rise to obstructive influences immediately after the operation, but the fear has no actual basis in fact. As soon as the ligatures are released, re-canalization occurs, and within twenty-four hours sloughing of the crushed edges further increases the size of the lumen.

Any fears of a late stenosis occurring are dissipated when sections of the anastomosis are inspected. So perfect is the line of union that within seventy-two days of the operation it is very difficult to find the situation in which the anastomosis was completed.

Special Advantages—The advantages of the method have been so often alluded to during the course of this description that it is sufficient to enumerate the more outstanding ones.

1 Complete asepsis is guaranteed, and numerous associated advantages are therefore obtained.

2 The operation can be performed in situations which are unsuitable for the ordinary methods of clamp anastomosis.

3 The operation is practically a bloodless one as far as the bowel portion is concerned.

4 The operation is completed in a much shorter period of time than is required in the ordinary methods.

SPECIAL NOTE—Since the foregoing article was written a point has arisen which we consider important to record. In the earliest clinical case which we attempted by the guillotine method, over-anxiety regarding the suture line led us to invaginate a greater amount of the bowel wall than was probably necessary. Seven months after the original operation a second operation was necessary to correct a diarrheal obstruction. It is apparent, therefore, that there is a danger in excessive invagination of the bowel wall.

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ON THE ORIGIN AND NATURE OF HERNIA.

By SIR ARTHUR KEITH LONDON.

(Being the Eleventh William Mitchell Banks Memorial Lecture given at the University of Liverpool November 1 1923)

HOW MITCHELL BANKS CAME TO LIVERPOOL.—It came about in the year 1869 that Edward Bickersteth, Senior Surgeon to the Liverpool Royal Infirmary, wrote to his old friend and teacher James Syme Professor of Clinical Surgery in the University of Edinburgh, about two matters which have a particular interest for us on this occasion. In the first place he tells Syme that "he is a firm disciple in the antiseptic theories and practice", and is "lost in wonder and admiration at this great discovery",¹ from which we see that the Senior Surgeon of Liverpool age 41, had been keeping a close eye on the doings of Syme's son-in-law, Joseph Lister in the Royal Infirmary of Glasgow. In the second place Bickersteth tells Syme that he needs an assistant. Thus it came about that William Mitchell Banks, age 27, strong in brain and limb, Edinburgh born and bred but of Liverpool origin on his mother's side took up his abode in the city which was destined to become the scene of his professional, social, and public achievements. He came to his new home just as the Listerian revolution was breaking. In this movement Mitchell Banks became a standard-bearer. He quickly realized that Lister had opened every region of the human body to surgical enterprise.

HIS TRAINING AS AN ASSISTANT.—There is another published letter which throws light on the kind of surgical recruit which Liverpool had thus added to its medical service. It is a letter written by Sir William Mitchell Banks in 1903—the year before his sudden death at the age of 62—to that splendid Lancastrian, Sir William Turner, Principal of the University of Edinburgh, but who when Mitchell Banks commenced the study of medicine in the autumn of 1859 was senior demonstrator in the dissecting room of Edinburgh University. "I can remember as vividly as possible the day I first saw you, in that terrible old dissecting room at the top of the long stans. I see John Athm with white beard and spectacles on nose, and a note-book and pencil in hand, I see Stirling with his apron on, peering into a microscope, Cleland is at a desk in a small room off the bone-room, Wilson is warming his back at the fire. You are taking names for 'parts' in a blue serge blouse and with a black velvet cap on your head. I even see that astounding fiend the porter carrying a body on his back down to the lecture-room. And now you are Principal of the University and covered with distinctions."² Here we have more than a vigorous vignette of his studenthood, we realize that in force and clearness of expression Mitchell Banks rivalled John Hilton, while behind it all is marked that passionate love of the past which many Scots have and a warmth of heart peculiar to himself which was one of the great assets of his life.

HIS THESIS ON THE WOLFFIAN BODIES—Sir William Turner has gone so has the old and intimate friend of Mitchell Banks' student days, Professor John Chiene but the great anatomist mentioned in this letter John Cleland, is still with us, as are two contemporaries of Cleland's—Sir James Crichton Browne and Professor W. C. McIntosh—vigorous and alert octogenarians. But in the letter just quoted there is no mention of the greatest figure of all—the tall, sombre master-anatomist, John Goodsir. Mitchell Banks dedicated his M.D. thesis "On the Wolffian Bodies"—a remarkable piece of research for a youth of 22—"To John Goodsir Esq., F.R.S.S. L. & E., with every feeling of respect and gratitude for the many kindnesses which he has shown the author." He loved and worshipped Syme under whom he dissected, for John Goodsir only 50 years of age in 1864, but moving swiftly to his end he had a profound respect. We see the influence of the seer-anatomist on this thesis. Our young author when discussing the reason why the Wolffian body undergoes such a remarkable metamorphosis during development, writes "The forces which induce these bodies so to act we can evidently know nothing of connected as they are in so intimate a manner, *with the original principle of life implanted in the cells which form them*." John Goodsir must have read this sentence with a peculiar sense of approbation.

HIS LEANINGS TO MIDWIFERY—If his thesis was done in Professor Goodsir's rooms, all the needed literature and references were supplied from the Midwifery Department—by Sir James Y. Simpson, clearly the thesis was intended to be a contribution to gynaecology, as if its author had a preference to specialize in this branch of medicine. This too, was the opinion held by Dr. Matthews Duncan*. But Edinburgh of 1864 had no vacancy for him in either anatomy, surgery, or midwifery, and after a brief adventure in Paraguay, Mitchell Banks became assistant in 1865 to one of the leading anatomists in Europe—Professor Allen Thomson, of Glasgow†. He arrived in Glasgow as Lister began to develop his system, he left that city for Liverpool in the same year as Lister succeeded Syme in Edinburgh.

A SURGEON ANATOMIST—Thus we see that the young man who arrived to assist Bickersteth of Liverpool in 1869 was trained, as were most great surgeons until Lister's time, in the dissecting room. Lister killed the surgeon anatomist—or nearly killed him—quite unintentionally. The old surgeon knew nothing of cleanliness, but he did study the machinery of the human body. And now the pendulum has swung to the opposite extreme, the young surgeon of to-day bends his best efforts to become a master of surgical technique, and is careless as to how the human body works. Mitchell Banks was a follower of Lister, but he also remained true to the ideals of the great surgeon anatomists of former times.

THE TREATMENT OF HERNIA—In 1876, when Mitchell Banks was appointed assistant surgeon to the Liverpool Royal Infirmary he was brought face to

* A statement made to the lecturer by Professor Rushton Parker.

† After this lecture was set up, I obtained a copy of a valuable semi-autobiographical address given by Sir William Mitchell Banks to the Anatomical Society of the University of Liverpool in 1904, the year of his death. In the preface to this lecture it is stated that he came to Liverpool in 1868 and that his visit to Paraguay took place after leaving Glasgow and before coming to Liverpool. A copy of this address has now been given to the R.C.S. Library by Mr. D. Douglas Crawford of Liverpool.

face with an ancient problem. How is a surgeon to relieve that prevalent infirmity of the human body—hernia? At the time of his appointment treatment by surgical measures was in the air. Lister had operated on two cases of hernia in 1871, Czerny was exposing, tying, and removing the peritoneal sac in 1876, very soon afterwards Annandale was operating on cases of hernia in Edinburgh Infirmary. Into this movement Mitchell Banks was drawn, and the treatment of hernia by means of surgical operation became one of the foremost interests of his busy life.

ARE HERNIAS UNDULY PREVALENT IN LIVERPOOL?—I suspect that hernia is unduly prevalent in the city of Liverpool and in the wards of its Infirmary. I find that not only was Mitchell Banks impressed by the magnitude and urgency of the problem,³ but so also was his colleague, Professor Rushton Parke,⁴ who performed his first operation for the cure of hernia early in 1879. At a later date, another Liverpool surgeon, Mr R. W. Murray, has been impressed by the importance of the same disablement and his book *Hernia its Cause and Treatment* (2nd edition 1910) represents a very important contribution to our knowledge of hernia. It was at Mr Murray's suggestion that Dr Nathan Raw examined the bodies of 200 subjects, both men and women, in Mill Road Infirmary. Although none of the subjects selected was supposed to have suffered from hernia yet in 47 of them potential hernial sacs were present. From these observations one infers that in every 1000 citizens of Liverpool, past middle age, 230 are the subjects of incipient hernia. Corresponding observations which I made on old people dying in London infirmaries showed that potential hernial sacs occurred less often—namely, about 120 per 1000.

WHY IS A MAN PECULIARLY LIABLE TO HERNIA?

I propose to devote this lecture, given in memory of Sir William Mitchell Banks, not to the treatment of hernia—for such knowledge lies outside my experience—but to attempt an answer to the question. Why should man be the subject of this infirmity so much more frequently than any other animal? As Sir Victor Horsley said in giving this lecture in 1914, the 'radical cure' of hernia is its prevention. To prevent we must first discover the cause, and the first step in any inquiry into the origin of hernia must be an accurate knowledge of its prevalence in our population and exact data as to the time of life at which the ailment first becomes manifest.

THE PREVALENCE OF HERNIA.—We have now at our disposal certain data which were collected when the manhood of the nation was examined for service during the late war.⁵ One of the most reliable sets of observations available is that made by Dr J. D. Cornie on 10,000 men, between the ages of 18 and 41 recruited in the south of Scotland, 36 men per 1000 were the subjects of hernia. In London and in the S.E. area the number of hernial subjects varied from 17 to 56 per 1000. In one group of Londoners, varying from 15 to 30 years of age the rate was only 6 per 1000, in those between 30 and 40 years of age the rate was 16 per 1000, in men between 40 and 50 years of age it was 24 per 1000. In a group of men recruited in Manchester and Stockport the rate was 125 per 1000. The result of a comparison of all the data

available leads me to believe that at least 20 out of every 1000 male inhabitants of Great Britain are 'ruptured'

In order to visualize the problem with which we have to deal, let us confine our attention for a moment to the population of Liverpool—805,000 in number. Let us suppose further that there are 400,000 males and that the average incidence of hernia—namely, 20 per 1000—holds for Liverpool. This gives us an army of 8000 males in Liverpool alone who are weakened by the presence of a hernia. No survey of women has been made, but the usual experience of surgeons is that hernias are six times more common among males than among females, so that to our army of 8000 males we have to add 1330 females. There must be in Liverpool about 10,000 beings—including babies, boys and girls, men and women—who suffer from hernial defects.

AGE-INCIDENCE OF HERNIA.—If we were to group the 8000 ruptured males in age-periods as in the following *Table*, we should find that hernia makes its first appearance much more frequently at certain times of life than at others.

TABLE SHOWING THE ONSET OF HERNIA, ACCORDING TO AGE *

AGE PERIOD	ONSET PER 1000	AGE PERIOD	ONSET PER 1000	AGE PERIOD	ONSET PER 1000
1st year	44	21st-25th year	30	46th-50th year	23
2nd-5th "	9	26th-30th "	29	51st-55th "	17
6th-10th "	6	31st-35th "	28	56th-60th "	14
11th-15th "	6	36th-40th "	26	61st-65th "	10
16th-20th "	25	41st-45th "	24	66th-70th "	6

* This table has been compiled from the following data: (1) It is presumed that the average incidence holds for Liverpool males—namely that 20 per 1000 are the subjects of hernia. (2) The onset of the hernia in each age group is based on data contained in that treasury of facts relating to hernia—Macready's *Treatise on Ruptures*—which although published thirty years ago still remains the standard reference book in the English language. Allowances have been made for the numbers removed from each of Macready's age groups by death.

In babyhood, during the first year of life, 44 out of every 1000 babies are hit or crippled by rupture, the incidence is more than double the average rate. Then in the second period of life—from the end of the 1st year to the end of the 5th—there is a partial immunity, the rate of onset drops to 9 per 1000, less than half the average rate. In the third period—from the 6th to the 10th year there is a further drop to 6 per 1000—the most immune period in a male's life-history. In the fourth, or 11-15 year period, there is a slight rise but it is not until puberty has been passed that the rate rises markedly, in the 16-20 year period it amounts to 25 per 1000—5 above the average. The second maximum—30 per 1000—is reached by the 25th year, thereafter there is a slight but steady decrease in the liability to hernia until the 50th year is passed. Thereafter men become gradually less liable to the onset of hernia until in the fifteenth age-period—from the 66th to the end of the 70th year—the rate of onset has again dropped to that of childhood. The main fact which such a table impresses on the student of hernia is that the baby sprawling in its nurse's lap, before it has learned to stand upright or to walk, and the young man in the zenith of his muscular development, are the most liable to become the subjects of hernia.

INGUINAL HERNIA OVERSHADOWS OTHER FORMS—In the above *Table I* have included all kinds of hernia—inguinal femoral umbilical and ventral. But when we look into the proportion in which the various kinds of hernia occur we see that the central problem is—What is the cause of inguinal hernia? If we take 1000 ruptured males we shall find that in 970 the inguinal region is the site of rupture—in only 20 has the femoral ring given way and in about 10 protrusion has occurred at the umbilicus. In females the incidence is different. If we take 1000 female subjects of hernia we shall find that 500 are hit in the inguinal region, 310 at the femoral canal and about 160 at or near the umbilicus. Even in women the inguinal variety is the prevalent type, in males it overshadows all the other forms. Femoral and umbilical hernias in women have a frequency largely in excess of that found in males. When we make all allowances it will be found that in every 100 cases of hernia dealt with by a medical man in general practice there will be 90 inguinal hernias, 7 femoral and only 3 umbilical. The real problem of hernia lies in the inguinal region of the abdomen.

UMBILICAL HERNIA AND THE EVOLUTION OF THE UMBILICUS—Although umbilical hernia is the least common type I am to consider it first because it gives us an opportunity of seeing how developmental or evolutionary hernias came into being. The manner in which the umbilicus comes into existence in the human embryo and foetus is well known, but if we are to understand the processes concerned we have to descend to a group of animals which lie near the stem from which the higher vertebrates including man, have been evolved. This group of vertebrate animals includes sharks, rays and dog-fish—known collectively as selachians. It was the great good fortune of the late Francis Martland Balfour, younger brother of Lord Balfour, to make the development of the selachian type of fish his special study, it was his great merit to recognize that the processes of development which he saw taking place in them were but simplified representations of the elaborate and obscure processes observed by those working at the development of higher vertebrates such as man. We have therefore to go humbly to the larval dog-fish to understand the origin of the yolk-sac, the placenta, fetal membranes, umbilicus, and umbilical cord in human beings.

AN UMBILICAL HERNIA IS NORMAL IN LARVAL DOG-FISH—One of the greatest discoveries made by living tissues in the course of their evolution was the use of capital—the provision of yolk or food on which the larval fish might live while developmental processes were being elaborated. In the embryo dog-fish part of the bowel is prematurely developed to contain the yolk, and before the larval form is ready to take to water, the yolk-sac is contained within a hernial sac formed from the ventral wall of the belly, and lined by peritoneum. As the larval stage is passed and the young fish begins to procure its own food, the whole hernia is gradually and spontaneously reduced and disappears, leaving no scar behind, here we see a hernia being produced and cured as a normal evolutionary event. The occurrence was well known to John Hunter, he also knew that in several types of shark the larval forms were hatched and reared in the Mullerian duct or uterus.

THE SAC OF AN UMBILICAL HERNIA REPRESENTS THE OLDEST FORM OF PLACENTA—It was the merit of Johannes Møller to carry our knowledge

of the larval dog-fish's umbilical hernia one step further. He found that in certain species where the eggs are hatched and reared within the mother, the wall of the umbilical sac of the larval dog-fish becomes interdigitated with the lining membrane of the womb and thus the developing animal, in place of being dependent on a hoard of food stored in a yolk-sac, could draw its sustenance from the liquid capital of the maternal body. But for this privilege a price has to be paid, the larval form has to sacrifice that part of its belly wall which, from being a hernial sac has been converted into a placenta. The placental sac is sloughed as the larval stage comes to a close, just as the antlers of deer are shed in the spring of the year. The point on the belly where the sloughing or necrosis takes place is marked by a wound and scar—the umbilicus.

CONGENITAL UMBILICAL HERNIA—In the human embryo the hernial umbilical sac is produced so prematurely that we may say it is developed almost before the embryo itself. The placenta and membranes represent an enormously expanded umbilical hernia of the belly wall, and it is at first lined with peritoneum, so that, at an early stage, the serous lining of the sac is infinitely greater than the part which remains within the body of the embryo. The contents of the sac are (1) the herniated fundus of the bladder, known as the allantois, and (2) the yolk-sac. Presently the neck of the hernia contracts and grows in length to form the umbilical cord, the yolk-sac itself goes with the placenta, its neck becomes drawn out into the vitelline duct, while the intestinal loop develops within the expanded neck of the sac. The growing intestinal loop continues in this developmental hernial sac until certain events take place in the opening weeks of the third month of foetal development.

THE MANNER IN WHICH THE UMBILICAL HERNIA OF DEVELOPMENT IS REDUCED—The events which lead to the reduction of the contents of this developmental hernia have been quite recently investigated and described by Professor J. E. S. Frazar.⁶ We have to concentrate our attention on the differentiating peritoneum and subperitoneal tissues—particularly on the mesentery attached to the hind-gut. A most orderly developmental or growth movement is seen to take place in various parts of the mesentery, thickenings are being formed along certain lines, adhesions are spreading in several definite directions and these changes lead to the rotation of the bowels their attachment in new positions, and the withdrawal of the intestinal loop from the umbilical hernial sac. It is true there are bands of non-striated muscle—such as that of Treitz—in the subperitoneal tissue, but the movements we have been describing depend not on muscular action, but on the mechanical effects which follow the developmental shortenings and lengthenings of the peritoneum. No one who has studied the manner in which the developmental hernia at the umbilicus is reduced can fail to be impressed with the formative properties resident in the foetal peritoneum and in its underlying tissue.

HEALING OF THE UMBILICAL WOUND—Within a week after birth the last remnant of the umbilical hernial sac—namely, the cord—has sloughed and a cicatrix is formed round its mouth. No pocket of peritoneum remains but the site is left with this weakness. Within the umbilical scar three cords terminate, derived from the umbilical vein and the two umbilical arteries and

yet though no peritoneal pocket is left we find that the age-incidence—or rather the time of onset—of umbilical hernias exactly parallel to that at the inguinal canal. To find a child born with abdominal contents in an umbilical sac is just as rare as to find an inguinal hernia at the time of birth. The umbilicus—and the same is true of the internal abdominal ring—is most liable to be the site of hernia in the first year of life—thereafter during childhood and on to puberty come the most hernia-free years of life. But with full growth and adult womanhood this immunity is lost. We cannot explain the age-incidence of umbilical hernia as we may inguinal hernia by supposing the former is due to the presence of developmental peritoneal pockets. When a hernia occurs in the umbilical area—either owing to the weakness of the serous tissue in infancy or to the stretching of the linea alba by obesity or pregnancy in adult life—a peritoneal pocket has to be formed anew.

THE DESCENT OF THE TESTIS REPRESENTS A PROCESS OF DIVERSIONAL HERNIATION.—I have dealt with umbilical hernia first and in some detail because the processes observed make the hernial descent of the testis* a minor and a more easily understood event. The process of extrusion of the testicle pales in importance when compared to the hernial protrusion at the umbilicus which led on to the formation of the placenta. The extrusion of the testicle represents a comparatively late event in the history of evolutionary changes. It did not come about until the mammalian stem was well under way—when a complete diaphragm had been formed and active movements involving running and jumping were evolved such movements being necessarily attended by high degrees of intra-abdominal pressure. Why the testis cannot withstand such pressures when it is in a state of active spermatogenesis I cannot tell, but I can offer no satisfactory explanation for its transit to the scrotum unless this supposition is true. In some animals the testes leave the abdomen only when they become the breeding homes of spermatozoa.

EVOLUTION OF THE GUBERNACULUM.—It is likely that the initial steps which led on to the descent of the testicle did not take place in the males, but in the females, of early marsupial mammals. Muscular bands descend from the inguinal part of the belly wall to support the pouch or marsupium in which the young are reared. I mention this supposition because in the early human foetus, and in many other foetal mammals, long before the descent of the testicle has set in, there is found a strand or cord of tissue issuing from the substance of the groin and passing to the scrotum or labium majus. Cleland named this inguinal strand the 'gubernacular cord'. Unfortunately that most able and lamented surgeon, the late Mr. C. B. Lockwood,⁸ mistook this preliminary inguinal strand of tissue for the basis of the real gubernaculum, and built up a theory—which still misleads many surgeons—that the testis is dragged down by muscular cords which are anchored to the scrotum, perineum, and groin. I have no hesitation in saying that John Hunter⁹ realized the nature of the process of testicular descent more fully, and gave a more accurate account of the structures concerned, than anyone has done since his time. If I had to add another contribution of more recent date to

* Nearly forty years ago Sir John Blund-Sutton recognized that the descent of the testis represented an evolutionary or developmental hernia.⁷

amplify Hunter's, I would name that made by Mitchell Banks' teacher—the veteran, Professor John Cleland¹⁰

HOW THE DESCENT OF THE TESTIS IS EFFECTED AND A DEVELOPMENTAL HERNIA PRODUCED—Every surgeon who has attempted to bring down a testis from the abdomen and place it in the scrotum knows how difficult the operation is. The vas deferens is too short, so are the spermatic vessels, and so is the pocket of peritoneum. Yet by a natural biological process this operation is successfully accomplished during the 6th, 7th, and 8th months of foetal life in the vast majority of children. At the end of the 4th month of foetal life we find a plica of peritoneum running from the epididymis and testis down to the future site of the internal abdominal ring. Within the plica are included bundles of foetal non-striated muscular tissue—so abundant in the subperitoneal stratum of the pelvic region. In the 5th month the plical muscular tissue undergoes a peculiar cellular hypertrophy to form the gubernaculum. The gubernaculum assumes a bulbous form, its thicker end being at its testicular extremity. In the latter part of the 5th and throughout the 6th month of foetal life the peritoneum, and particularly the subperitoneal tissue, takes on a peculiar form of growth, evaginating the adjacent abdominal wall and apparently pushing its way towards the groin. If in the 6th month one takes hold of the gubernacular bud with a pair of forceps, the slightest degree of pull is sufficient to separate the growing or inguinal end of the gubernaculum and the surrounding hood of peritoneum from the recess it is creating in the groin. All the layers of the belly wall in front of the gubernacular bud are soft, growing and being evaginated. If we ask how such an effect can be produced, we must attribute it to the influence of the gubernacular bud, such an inference is justifiable when we see the way in which a developing optic cup can cause the overlying ectoderm to form a lens, or the manner in which connective tissue can compel cultures of embryonic epithelium to form tubes.

THE DESCENT IS BROUGHT ABOUT PURELY BY DEVELOPMENTAL CHANGES.—By the 7th month the gubernacular bud and its hood of peritoneum have made their way into the abdominal wall, the testis follows. The gubernaculum retains the same length during the act of transition through the belly wall, this part of the transit occupying the 7th month. Behind the testis a process of growth is at work, elongating the vas, the vessels, and the peritoneum. The gubernacular bud follows the course of the preliminary inguinal strand already mentioned, pressing its nose into the strand. The process of transition is effected entirely by developmental or growth changes of exactly the same kind as brings an abscess, an encased piece of bone, or a foreign substance to the surface of the body. It is a process managed like the retraction of the intestinal loop from the umbilicus by properties resident in developing peritoneum and subperitoneal tissues. By the 8th month the gubernacular bud has traversed the abdominal wall and by the 9th it and its hood of peritoneum have established themselves in the scrotum. For some time it will be found that the testis, gubernaculum and peritoneum can be detached from their hold in the scrotum with the greatest of ease, for they are fixed only by the layer of growing cells. Presently these cells form adhesions and the gubernaculum becomes reduced to form part of the attachment of the testicle to

its nest within the loose tissues of the scrotum. In the transition of the testes the gubernacular had rarely missed its way, it follows the line of the inguinal strand to the fundus of the scrotum, but occasionally it stops short in the groin or it may overshoot the mark and enter the perineum or it may turn inwards to the root of the penis or outwards to the thigh.

HEALING OF THE WOUND OF TRANSIT—This remarkable and severe operation being completed by the end of the 8th month of fetal life there remains a month before birth for the parts concerned to heal up. The neck of the peritoneal diverticulum lying within the freshly formed inguinal canal is new; it has been specially formed during the period of descent—only the fundus of the diverticulum—the tunica vaginalis—is old. Hence we need not be surprised if we find the same changes taking place within the peritoneal funicular process as those we see occurring in the mesenteries of the abdomen during their fetal fixation. The obliteration of the peritoneal canal proceeds slowly—even in the 3rd month after birth there are still 30 to 40 children in every 100 in whom the upper part of the canal is imperfectly closed.

WHY IS HERNIA MOST OFTEN PROMOTED IN THE FIRST YEAR OF LIFE. We have seen that the internal ring is more liable to be the site of hernia in the first year after birth than at any other period of life. We may be inclined to attribute this liability to the tissues of the inguinal region having failed to undergo perfect healing after the severe operation they have experienced to permit the transit of the testis. Man is not alone in this matter, most other mammals have to submit to the same operation and inguinal hernia is rare in them at every stage of life. Nor can the frequency of hernia in infants be attributed to the patency of the process of peritoneum, this process remains open in nearly all animals—man and the gorilla being exceptional in having it closed. Nor can it be the assumption of the upright posture for the infant on its mother's lap cannot be described as upright. Nor is it walking, for in the second year the liability to hernia is much less than in the first.

WHY DOES REMOVAL OF THE PERITONEAL POCKET CURE A HERNIA?—My friend Mr. Hamilton Russell,¹¹ and those who believe with him that the presence of a developmental pocket of peritoneum is the sole circumstance which occasions a hernia, will put a very pertinent question to me. They will ask me: Why is it, then, that the removal of such a pocket from the groin of a child cures that child of hernia? My answer is that the operation has done much more than remove a peritoneal sac, it has rendered the sphincteric mechanism of the inguinal canal again competent*. If I put a washer on a leaking tap, I do not claim I have put on a new tap, only made the old one competent. To occlude the mouth of a peritoneal sac is the equivalent

In the *BRITISH JOURNAL OF SURGERY* (1923, vi, 148), Mr. Hamilton Russell gives in internal view after closure of femoral sac by torsion "It will be seen that Mr. Russell has not only removed the femoral sac, but he has very effectually occluded the femoral ring by twisting a plug of peritoneum into it. When consolidated this plug should form an effective barrier against further protrusion of abdominal contents. Mr. Russell relies on an article published by Mr. Allison Panton (*Four of Anal* 1923, lvi, 106) for proof of the congenital origin of hernial diverticula at the femoral ring. If he will read Mr. Panton's article again he will see that Mr. Panton has proved no such thing. Like Mr. Russell, he only hopes the sacular theory is true.

of placing a washer on a tap. The leak in the tap is remedied by tying the mouth of the sac as high as possible. The ligature which is put on the disturbance which is created in the field of operation, give rise to an inflammatory and healing reaction which consolidates parts round the internal ring. Removal of a sac would be of no avail unless the stopcock mechanism of the groin were efficient. The presence of an open inguinal ring only makes it easier for the bowel or omentum to force the inguinal sphincter—or shutter, as I should prefer to name the structure, but we shall see that there is the most ample evidence that the inguinal shutter can be forced whether there is an open sac or not.

Why, then, is man so much more liable to hernia—particularly to inguinal hernia—than any other animal? It cannot be because his inguinal canal is open, it is his prerogative to have it usually permanently closed, yet he suffers more than animals with the canal permanently open.

THE INGUINAL 'SHUTTER'—Before returning a definite answer let us look for a moment at the manner in which man's inguinal canal is guarded. There are two guards, an outer and an inner. The outer guard consists of that part of the external oblique which rises from the 8th, 9th, and 10th ribs, and ends over the flank on each side of the external ring. Every time we stand up, in every effort we make, this muscular guard is set reflexly into action and strengthens the outer wall of the inguinal canal. The inner guard is more complex. It consists, in the first place, of Poupart's ligament, a structure peculiar to man. The essential part of the inner guard is represented by the conjoint muscle—that part of the combined internal oblique and transversalis which, rising from the outer part of Poupart's ligament, passes above the internal ring to end in the conjoint tendon. The tendon of the conjoint muscle is inserted in the crest of the pubis in front of the rectus abdominis muscle. When the conjoint muscle is relaxed there is an interval between its lower border and Poupart's ligament filled by the transversalis fascia and peritoneum. When the muscle contracts, its lower edge becomes pressed against and flush with Poupart's ligament, thus closing the inguinal gap. This is why I prefer to describe the conjoint muscle as a shutter rather than as a sphincter. The underlying mechanism is similar to that which shuts the eyelids, the lower lid like Poupart's ligament, being almost stationary. If the 12th dorsal nerve is stimulated in the loin, the shutter closes hard down against Poupart's ligament. If we place a finger on the groin when about to cough, we shall feel the shutter close before the expulsive effort is made. If we stand up we shall feel it tightening and closing in the act of rising. It is worked by a reflex nerve mechanism. Any failure in this reflex will lay the groin open to hernia. Who has looked if this reflex is effective or not in the groin of those infants who suffer from hernia? Will not a disturbance along the gastro-intestinal tract inhibit the working of this reflex?

MAN'S GROIN HAS BEEN WEAKENED DURING HIS EVOLUTION—Man is liable to hernia on account of two circumstances. The first is that the shutter-mechanism of his groin has been weakened by the adaptations his pelvis had to undergo—not for the upright posture,¹² but for his mode of progression. Every step a man takes involves a balancing of his body on the head of one of his thigh bones. In this act the pelvis has to serve as a complex series of short

levers. For this reason his grom has undergone a series of changes—the conjoined muscle has been made less efficient owing to the necessity of having a Poupart's ligament. The second reason for man's liability to hernia is the fact that he has not only to balance his body on his thighs but also to maintain his trunk stiff and erect by the action of muscles of his abdominal wall. Over and above this he has become an animal of labour, entailing high and intermittent degrees of intra-abdominal pressure of a kind which are unknown in the bodies of other animals. There is reason to suspect too that the reflex muscular mechanism which guards the weak area of his grom may break down. Further on we shall see that it is not continued degrees of high intra-abdominal pressure which cause hernia but minor and oft-repeated impulses which in time wear down the defences of the grom and pelvic floor and lead to the production of hernial protrusions.

And there is one other matter which requires further observation. We are so apt to look on tendons, fascial structures and connective tissues as dead, passive structures. They are certainly alive and the fact that hernias are so often multiple in middle-aged and old people leads one to suspect that a pathological change in the connective tissues of the belly wall may render certain individuals particularly liable to hernia.

THE PULMONARY CAVITIES REPRESENT INTERSTITIAL HERNIAL SACS—We have seen that the two regions of the belly wall—the umbilical and inguinal—are the sites of developmental or evolutionary hernia and that these regions may become after birth the points at which hernial protrusions take place. There is a third site at which herniation occurs as a regular developmental process—namely, the region of the diaphragm. The lung, like the testis, is originally an abdominal organ. The pleural cavities represent hernial diverticula of the abdominal cavity produced by developmental means.²³ The pleural diverticula in point of evolutionary history, are older than the scrotal diverticula but more recent than the umbilical. The umbilical and scrotal are complete hernias, involving all the layers of the belly wall, the lungs, on the other hand, come to lie in an interstitial sac, the diaphragm represents the inner layer of the apical or cervical wall of the primitive abdomen, the pleural diverticula as they develop, separate the inner or diaphragmatic muscular layer from the neck, and thus it comes about that the lungs lie within an interstitial sac excavated in the cervical wall of the primitive abdomen.

CONGENITAL HERNIA OF THE DIAPHRAGM—In the course of development the mouth of the pleural diverticulum comes to lie in front of the neck of the 12th rib—its site being marked by the hiatus between the crural and costal fibres of the diaphragm. The mouth of this sac becomes closed by the thickening of the peritoneum at the pleuropertitoneal junction before the end of the 2nd month of development. Here again the plastic properties of the peritoneum secure the closure of the hernial sac.

If the opening fails to close, then the contents of the abdomen grow on and are pressed through the pleuropertitoneal passages, compressing the lungs. It is exceedingly rare for a hernia to occur on the right side, for the liver serves to block the passage, but it is otherwise on the left side, hence the usual congenital diaphragmatic hernia lies on the left side, and the protruding

organs are those which occupy the left hypochondrium and umbilical regions of the abdomen. Developmental processes of the liver may grow into the diaphragm, pushing covering sacs in front of them into the pleural cavities or pericardium.

Another and rare congenital opening in the diaphragm—of unknown evolutionary significance—may occur behind the 7th costal cartilage and become the site of a hernia. Another form concerns an apparent hernia of the stomach into the posterior mediastinum. The stomach is originally almost cervical in situation, but as the pleural diverticula expand and the diaphragm descends, the œsophagus becomes elongated, and thus the stomach also descends, maintaining all the way a subdiaphragmatic position. If however, the œsophagus does not elongate, the descent of the stomach is arrested, and thus we find it placed within the posterior mediastinum surrounded by its sac of peritoneum*. Here the hernial sac is formed not by a protrusion of the organ, but by the downward movement of the diaphragmatic wall drawing a sac over the stationary stomach. The œsophageal orifice, however, may become the site of a true protrusion of part of the stomach—particularly in cases of visceroptosis. The hernial sac in such cases is not of developmental origin.

For our present purpose diaphragmatic hernias following trauma are not instructive. They represent true 'ruptures'. My friend Mr. David Geig¹⁴ has shown that wounds of the diaphragm do heal, but one may suspect that constant contractions make their sound union difficult and unusual. There are also cases, such as was shown to me by Dr. J. M. Woodburn Morrison,¹⁵ where the left dome of the diaphragm was protruded within the thorax so as to form a cup-like hernial sac.

THE PRODUCTION OF HERNIAL SACS AFTER BIRTH

So far we have been dealing with hernias which occur at sites where processes or evaginations of the peritoneum take place in the development of every child. We are now to pass on to sites where we know for certain that no peritoneal pocket is formed during any date in the development of the human child. These sites are the femoral ring, the obturator canal and the vaginal passage of the pelvic floor. The last is probably the most frequent site of hernial protrusion to which women are liable. Why, then, are these sites liable to hernia and how are protrusion of the abdominal contents produced at these points?

HERNIAL PRODUCTIONS ARE NOT CONFINED TO THE ABDOMINAL CAVITY.—It will assist us to answer these questions if we leave the abdomen aside for a moment and note the manner in which hernial protrusions are produced in other closed cavities of the body. A spina bifida is a hernia of the spinal contents arising early in foetal life from an increased pressure in the cerebro-spinal-fluid system. Occipital and frontal encephaloceles are of the same nature: they are localized protrusions of the cranial contents, produced not

* See J. B. Hume's description of a case in the BRITISH JOURNAL OF SURGERY 1922, v. 207.

by muscular compression as in the abdomen, but by an increased amount of and heightened pressure in the cerebrospinal fluid. We may have a hernia of a contracting muscle protruding through a defect in its sheath. The most instructive examples, however, are to be found in that series of closed sacs which linked together form the alimentary tract.

THE PRODUCTION OF RETROPHARYNGEAL POUCHES.—The most instructive site to study the manner in which hernias of the abdomen arise is the pharynx. A retropharyngeal pouch is a hernial sac developed by repeated pressures out of the lining membrane of the pharynx. It is certainly not of developmental origin. Such pouches are extremely rare under 20 years of age; men and women become most liable to their formation as the age of 40 is approached or passed. They always form at the same site,^{16 17} they emerge from the posterior wall of the pharynx between two parts of the inferior constrictor: the upper or retrothyroid part and the lower or retrocricoid. These two parts of the same muscle serve totally different functions. The retrocricoid or lower part forms a collar round the orifice of the œsophagus and serves as a sphincter for this orifice. The retrothyroid or upper part of the muscle is the main agent in forcing the swallowed mouthfuls from the pharynx into the œsophagus. Between these two parts of the inferior constrictor there is when the posterior aspect of the pharynx is examined a narrow lozenge-shaped area, occupied by smaller bundles of muscular fibres. It is in this lozenge-shaped interval that retropharyngeal pouches begin their protrusion. Professor F. G. Parsons has presented to the museum of the Royal College of Surgeons a specimen—a man's larynx—which shows the first stage in the formation of a pouch.

When a mouthful of food or of drink is transferred from the mouth to the pharynx, a series of events immediately follows. The opening to the larynx is closed, the mouth is cut off from the pharynx, so are the nasal cavities. The constrictors of the pharynx, chiefly the inferior member of the series, seize the bolus, the sphincter to the œsophagus relaxes, and the bolus is forced within the œsophagus and sets out on its journey to the stomach. I have recently estimated the pressure generated within the pharynx as each mouthful is forced within the œsophagus. I found that it was much greater than I anticipated. When the bulbous end of a rubber tube which is filled with water and connected with a mercury manometer is swallowed I found that the pressure generated in the pharynx forced the mercury column to a height which varied between 40 and 50 mm. of mercury above zero. As each mouthful is swallowed, a pressure is generated which will support a column of mercury between 40 and 50 mm. high. The wonder is, not that retropharyngeal pouches occur, but that they do not form more frequently than is actually the case. One might suppose that a delay in the relaxation of the sphincter of the œsophageal orifice would conduce to their production, but were this so we should expect pouches to recur in those cases where they have been removed. This does not seem to happen. I therefore infer that pharyngeal pouches result (1) From a weakness—perhaps a developmental weakness—in the lozenge-shaped area at the junction of the propelling and sphincteric parts of the inferior constrictor muscle, (2) From the repetition of intermittent impulses of high pressure generated during each act of swallowing causing

the weak area to stretch and actually grow. The pouch is not formed by a mere extrusion of the lining mucous membrane. At first it has its covering of muscular fibres. The pouch is not a thin and extended slide or avalanche of the lining membrane of the pharynx, but is produced by growth, stimulated by the extruding forces which constantly act on it. Herein we have a demonstration that hernias can be formed and are formed—as a former generation of surgeons believed—by forces acting on a weakened part of the containing wall.

HERNIAL PROTRUSION OF THE LINING MEMBRANE OF VARIOUS PARTS OF THE BOWEL — *Duodenal Diverticula*—I need not stay to discuss diverticula which are produced from the œsophagus or stomach, but pass on to those hernial protrusions of mucous membrane of the duodenum which occur so frequently at the point where the common bile-duct perforates its muscular wall. The perforation of a duct through the wall of a closed sac—be it duodenum or bladder—is the weakest point in the wall of that sac. When one thinks of the matter it will be realized that the safe transit of a duct through the muscular wall of a saccular organ is really a difficult problem. Nature has done her best to solve the difficulty by attaching both circular and longitudinal muscular fibres of the bowel to the wall of the perforating duct. Even then the wall of the bowel is weakened at the point of perforation of the duct, and hence hernial protrusions of the mucous membrane of the duodenum occur almost always to the right or to the left or on both sides of the point of perforation. What are the forces or pressures which lead to the formation of these hernial protrusions? Diverticula occur most frequently in cases of visceroptosis, when one may suspect that the exit of contents from the duodenum is rendered difficult by the traction of the superior mesenteric artery. I suspect the stasis in the duodenum is more frequently due to a sphincteric action of muscle at the terminal part of the duodenum. Pockets of developmental origin are exceedingly rare in the duodenum.

Jejunal Diverticula—Then, in the first part of the jejunum hernial protrusions of the mucous membrane are not uncommon. They are always produced within the narrow zone to which the mesentery is attached. But their site of origin is not determined by the absence of the peritoneal coat along this zone, but by the fact that it is along this uncovered line that veins emerge and arteries enter and perforate the muscular wall of the bowel. A vein may be engorged one moment and half-empty the next—the point of venous perforation presents a potential space or opening, and it is just at such points that these hernial protrusions of mucous membrane occur. The pressures which generate them are those produced by the strong muscular coats of the wide-lumened jejunum.

Diverticula of the Sigmoid—Passing next to the most common site of all at which hernial diverticula occur—the sigmoid colon—we are embarrassed by a complete ignorance of the functions carried out by this tract of bowel. We note that the hernial sacs usually occur at the sites of vascular perforation both at the points where vessels pass to the appendices epiploicæ and along the line of mesenteric attachment. We note that this tract of bowel when it has become the seat of diverticula¹⁸ has its interior cut up into a series of communicating cavities separated by inflected semilunar partitions. The

condition of the musculature of the sigmoid or iliac colon when it is the site of diverticula leads one to suppose that there has been a disordered action of the musculature—that the iliac colon is broken up into a series of segments each in a state of spasmodic contraction. Diverticula of the sigmoid like the corresponding pouches in the pharynx duodenum and jejunum do not begin to form until adult life is reached. They are commonest in middle age. In late stages of the disorder pockets will form at other sites than those of vascular perforation. Although we are unable to tell why one person is more liable to diverticula of the sigmoid than another we cannot overlook the fact that pockets formed in the wall of this part of the colon are of the nature of hernia. The pressure which produces these diverticular hernias is generated by the spasmodic action of the muscular wall of the sigmoid and the sites of formation are determined by the points of vascular passage.

THE FUNCTIONAL SIGNIFICANCE OF THE CRURAL CANAL AND FEMORAL RING—Let us now apply the information set out in the foregoing paragraphs to the explanation of hernia at the femoral ring. At no point of the development of man or beast does an evagination of the peritoneum take place at the femoral ring. The formation of a femoral hernia in childhood is exceedingly rare, hernial formations at this site increase in frequency as puberty is passed, they attain their highest incidence of onset about the age of 40. Why is there a femoral ring, and why should man be the only animal which suffers from hernia at this site? The space between Poupart's ligament and the underlying bony hump of the pelvis is divided, as everyone knows into a larger outer or muscular compartment and an inner or vascular compartment. We have seen that the point at which vessels perforate the muscular wall of a closed sac is a point of weakness, the abdomen is a closed cavity with a muscular wall and the great iliac vessels perforate its lower wall to enter the thigh. When we stand, particularly if we walk or run, the femoral vein is goaded as it passes under Poupart's ligament, it needs all the available space provided by the vascular compartment, there is then no empty space left—no crural canal or femoral ring. But when we recline and rest, the femoral vein becomes less distended, and there now appears a space to the inner side of the vein, which we call the crural canal, the orifice of this space we call the femoral ring. The crural canal is to permit the femoral vein to enlarge when engorged under the stress of exercise. We have here a safety mechanism and it is just this mechanism which provides the potential space for hernia.

THE MANNER IN WHICH THE FEMORAL RING BECOMES DISTENDED—The crural canal just mentioned is of normal size and produced for a physiological purpose. We have now to inquire into the forces which lead to an enlargement of the canal and the protrusion within it of abdominal contents, carrying a sac or diverticulum of peritoneum in front of them. There is no need to analyse the reasons why the sub-Poupartian vascular compartment is relatively large in women, this matter has been investigated recently by Mr J. Allison Panton.¹⁹ The femoral compartment of women is relatively large (1) Because of the sexual growth undergone by the pubic part of the pelvis at puberty. (2) Because the iliopectas of woman is relatively small compared with the size of her sub-Poupartian space.

A consideration of the forces which lead to a pathological enlargement of the femoral ring brings us face to face with the kind of force involved in the production of all kinds of hernial openings of the belly wall. Some years ago I drew attention to the venous cistern from which the heart is filled.²⁰ The iliac veins form part of this cistern. Through the external iliac veins the venous cistern extends as far as Poupart's ligament. These venous valves are stationed which cut off the femoral veins from pressures generated within the great venous system of the trunk during exercises. We have thus the lower ends of a fluid column of venous blood lying within the vascular compartments at the groin, and filling, when we stand or sit, the potential spaces called the crural canal. Every effort we make compresses* the venous cistern within our bodies, and tends to force the blood into the thighs which would happen were it not for the sub-Poupartian venous valves. Thus in reality we have lying at the site of femoral hernia a kind of water-hammer, with every effort, with every cough with every movement of the trunk the venous column within the vascular compartment undergoes a quick distention, expending a sharp blow on the tissues which surround it—particularly those forming the femoral ring. It is not the steady effort but the repeated impulse, such as occurs in coughing, which leads to the expansion of the femoral ring. The same is true of the veins entering the abdomen from the testicle at the internal abdominal ring, the venous impulse tends to enlarge the orifice.

FAT AS A FACTOR IN THE PRODUCTION OF HERNIA—We too often forget that fat, in the living body, is a semifluid substance. Its semifluid qualities are used where easy movement of adjoining parts has to be permitted and the generation of vacua prevented. The subpatellar pad of fat sinks into the inequalities of the knee-joint and prevents the production of vacua during the movements of the femoral condyles. The Haversian bursa of fat at the open portal of the hip-joint rushes in as interarticular spaces develop during certain movements of the thigh. The kidneys are surrounded by a peculiarly fluid fat to allow them to swing easily in the respiratory tide. Every subperitoneal pellet of fat represents a miniature water-hammer. We know how they can be forced through vascular foramina in the linea alba under compressive forces generated in the upper part of the abdomen. The peritoneum over the femoral ring has a loose binding, and the subperitoneal tissue there is usually lined with fat and often a lymphatic gland lies over the ring. Thus at the femoral ring we have the ideal conditions which may lead on to hernia—a potential space for passage of the distended femoral vein—a movable hammer-head represented by subperitoneal pellets of fat—and high intermittent pressures generated in the abdomen during muscular efforts or respiratory disorders. Further the living pocket of loosely-bound peritoneum carried out as a diverticulum by expulsive efforts is a growing plastic thing, we find that as the fat carrying the pocket is expelled, the mouth of the sac may become narrow or even closed†. I suspect too, that fluid often

* For a statement of the pressures generated within the abdomen during exercise, see 'Visceroptosis', Allbutt and Rolleston's *System of Medicine*, 1907, iii, 860

† See Mr. William Eccles *Treatise on Hernia*, 1902

collects in these pockets as they begin to form and the presence of fluid serves to increase the hammer effect. How plastic the pockets of peritoneum thus expelled are, and the remarkable forms which they may assume will be seen from descriptions of femoral sacs given by Mr Hamilton Russell and Mr R W Murray.

That subperitoneal masses of fat may be expelled beneath Poupart's ligament so as to lie in Scarpa's triangle is well known. My friend Dr Gladstone²¹ has recorded a case where a mass of subperitoneal fat had become herniated into the right thorax through the site of the old pleural passage. The same writer has called attention to the fact that peritoneal diverticula within the obturator canal are carried out during the expulsion of subperitoneal masses of fat.

HERNIATION OF THE BLADDER—We see the principle of the water-hammer at work in cases where the bladder becomes extruded as a hernial content. It may pass out at the femoral ring, at the internal abdominal ring or at the obturator canal, but the most usual site of its herniation is the vaginal passage of the pelvic floor. To permit the easy filling of this organ, the peritoneum is but loosely bound to the anterior pelvic wall and to the regions lying round the sites of femoral and of direct inguinal hernia. The peritoneum is loosely bound in the iliac fossa to permit the movements of the iliopsoas muscles as well as the filling and emptying of neighbouring visceral structures. When the bladder becomes partly or completely filled with urine, its contents are thrown into impulses with each compressive movement of the abdominal walls. These vesical impulses beat against those parts of the abdominal and pelvic walls with which the bladder lies in contact. These impulses seek out the weak points in the surrounding wall, just as a distended inner tube seeks out and tends to dilate at any weak point in the overlying cover of the tyre. The filled or partly-filled bladder, under the forces generated within the abdomen, becomes a water-hammer hitting against and gradually enlarging the weak places in the containing wall of the pelvis and lower abdomen. It is the defence at the vaginal passage which is usually worn down, it is the repetition of minor strokes which gradually works the damage at hernial sites—not the pressure generated by a great effort—although the latter may often complete the damage and produce the external visible prolapse or hernia.

THE PRODUCTION OF RETROPERITONEAL HERNIA—A consideration of the manner in which retroperitoneal hernias come to be formed within the abdominal cavity brings to light another force which can distend recesses of the peritoneum so that they form hernial sacs. The formation of hernia by the distention of certain peritoneal pockets in and near the roots of mesenteries was dealt with by Sir Berkeley Moynihan nearly a quarter of a century ago.²² He found, as others have done since, that hernia through the foramen of Winslow and into that great peritoneal pocket which lies behind the stomach is excessively rare. One reason, no doubt, is that there are no knuckles of small bowel in the neighbourhood of the foramen. But why is the hepatic flexure of the colon so rarely thrust within the foramen of Winslow? The reason is that any rise of intra-abdominal pressure acts with just as much force to keep the foramen of Winslow and its peritoneal sac shut as it does to thrust the hepatic flexure into the foramen. If the foramen

of Winslow was situated in the wall of the abdomen and its sac lay outside this cavity then, on any movement of the body, a hernia would be formed at the foramen of Winslow. The same reasoning holds for all the retroperitoneal fossæ. I look on the duodenal fossa or pocket as serving the purposes of a bursa for the terminal part of the duodenum. If the duodenum has a difficulty in forcing onwards its contents, the duodenal fossa becomes enlarged. It is only a potential fossa as long as the duodenum is active and full. I am convinced that the great retroperitoneal sacs described by Sir Beakley Moynihan and others cannot be regarded as produced by developmental means. What, then, is the force which has led to the expansion of miniature peritoneal recesses into great hernial sacs? There is but one force which could bring about such a result, and that is the pressure exerted by a segment of bowel when it seeks to force its contents forwards against an obstruction. I suppose that a knuckle of bowel during a peristaltic movement forces its convexity into a duodenal or similar fossa, that within the fossa the knuckle is partly occluded, and that the segment of bowel proximal to the entangled knuckle forces in more contents, thus enlarging the pocket. This operation is repeated time after time until a hernial sac big enough to contain the whole of the small bowel is produced. A consideration of retroperitoneal hernia shows us that the peristaltic action of a knuckle of bowel within a small sac may in time make it into a large sac. The bowel, under the force of its peristaltic movements plays a part in the formation of hernial sacs.

THE FREQUENCY OF PERITONEAL POCKETS AT THE SITES OF HERNIA IN THE AGED—How does it happen that so many people after the age of 40 show one or more peritoneal pockets at the site of the femoral ring, and not infrequently beneath Poupait's ligament to the outer side of the femoral vessels? We saw that in Liverpool Dr Nathan Raw found in 200 bodies 52 femoral pockets, although not so frequent in London subjects, yet they occur in great numbers. Mr Murray inferred that such pockets must be of developmental origin to account for the frequency with which they occur. If this were so, those who like myself, have examined large numbers of foetuses and children must have come across them. They have never been seen before birth, they become more numerous in each decade of life after the second. Another reason given for believing them to be of developmental origin is that these sacs rarely contain bowel or omentum. They are found to be empty in the dead body. It has been the universal experience of surgeons, as of Mr Murray himself, to observe that when a patient lies down a hernia in an early stage of formation becomes reduced and its sac empty. The patient has to be asked to cough or to bear down as at stool, to fill the hernial sac. These pockets observed by Dr Nathan Raw were incipient hernial pockets, in the supine dead then contents naturally fell out and they were found empty. If these people had lived and suffered the contents would in time have filled their sacs and have become irreducible. As I have shown, all the conditions and circumstances needed to give rise to hernia exist within the abdomen of adults, hernia will form in any and every one if there is but a weak enough area in the abdominal wall and a constant repetition of intra-abdominal pressure. The living peritonæum is the most ductile of structures.

HERNIAL POCKETS MAY BE OF DEVELOPMENTAL OR ACQUIRED ORIGIN —

I come now to sum up the inferences which must be drawn from the evidence relating to the etiology of hernia set forth in this lecture. At the present time surgeons hold quite diverse views as to the origin of the peritoneal sac which surrounds a protrusion of abdominal contents. There are those, belonging to the school led by Mr Hamilton Russell, who maintain that hernial sacs are of developmental origin, that after birth they cease to form, and that if a child, man, or woman has no pre-formed sac, then one and all of them will be free from hernia throughout their lives. There is the older school, represented by Mr McAdam Eccles and Mr Jonathan Hutchinson, who hold that sac formation does not cease at birth but may arise under suitable circumstances at any stage of life. No one who has rightly surveyed the evidence to be gleaned in embryological laboratories, hospital wards, daily practice, and post-mortem rooms can doubt for a moment that these followers of the old school are right. Given a weak point in the abdominal wall, there can be no doubt that the intermittent and repeated forces which are generated within the abdomen of every man and child are sufficient to protrude that weak, but living and plastic area in the form of a hernial sac. All femoral hernias are produced in this manner, so are all extrusions of the bladder and uterus, and so are all direct inguinal hernias and hernias at the umbilicus, for none of these is there a vestige of reasonable evidence that the sac was formed before birth and by developmental means. As to hernias which escape by the inguinal canal, the evidence is more difficult to decipher, but taking all the lines of evidence into account, one may conclude that most of the hernias of infancy take place into the funicular process, a sac of developmental origin, and that after childhood the sac and hernia are formed together and simultaneously. The fact remains that in many infants hernias do not form although the process is patent, and the same holds true for animals, in which this process remains open throughout life. The presence of a sac is not the essential circumstance which leads on to the formation of hernia.

Bearing of the Theory of the Causation of Hernia on the Workmen's Compensation Act—The etiology of hernia has an important bearing on the administration of the Workmen's Compensation Act. American surgeons, led by Mr W B Coley,²³ take Mr Hamilton Russell's point of view, and hold that hernias always descend into pre-formed sacs. The only kind of hernia case entitled to compensation in this Committee's opinion is one in which the protrusion appears suddenly and with pain, and as a result of an accident or of a great muscular effort. There must be proof that the subject was free from hernia before the accident. If the Committee had been logical, it should have made no exception whatsoever.

If the evidence and the inferences as to the origin of hernias put forward in this lecture are right, then by far the greater number of subjects of hernia are properly excluded from recompense under the Workmen's Compensation Act. Hernias which occur in adult men and women are all of them, or almost all of them, of gradual production, repetitions day by day of straining at stool, stooping, lifting, coughing, and all the other bodily movements cause the semifluid abdominal contents to beat against their containing walls and

gradually to evaginate the weakest points of the abdominal wall. There may be a disorder of the muscular mechanism of the groin—as there often is, the region of the internal ring, or of Hesselbach's triangle, or of the femoral ring may become distended, the connective tissues may undergo a degenerative change. From bowel trouble or constipation, from respiratory disorders, or from an apparently innocent game of golf, expulsive forces may be generated which give rise in the course of time to hernial protrusions, then a sudden effort, which in a normal man would be harmless, turns a partial or incipient hernia into a real one. It would be unjust if compensation should be paid under such circumstances. And yet it may be just a special effort which a workman is called upon to make which brings about the actual protrusion of contents, if he had not been called on to make a special effort the strength of his inguinal structures might have served him without accident. I never see a young lad climbing a steep ladder with a heavy sac of corn on his back without feeling that but for the grace of a strong and perfectly competent groin he must quickly become the subject of hernia. So far, inquiries into special trades and occupations, such as gardening, coal-heaving, etc., have failed to give positive evidence that certain occupations are specially liable to cause hernia. Hernia occurs in all classes and at all ages. In the London recruiting returns it is said that 5 per cent of barbers suffer from hernia.

The Importance of a Right Understanding of the Etiology of Hernia—

It is most important that surgeons should form a just and true opinion concerning the manner in which hernias arise. If they occur only in those who have hernial sacs already formed during foetal life then we must either excise the sacs at birth or stand by and do nothing but trust to luck. But if the old surgeons such as Mitchell Banks were right in believing that hernias may form at any time of life and are produced by forces generated within the abdomen during efforts, both great and small, and that the occurrence of hernia is due to circumstances over which we have control, then the prevention of hernia is a matter worthy of our serious study. It is for this reason that I have chosen the etiology of hernia as a subject for the Mitchell Banks Lecture.

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ACUTE PANCREATITIS

BY H. J. WARING, ASSISTED BY H. E. GRIFFITHS, LONDON

DURING the past decade a number of patients suffering from acute pancreatitis have come under my care, and upon most of them I have operated and been able to follow the ultimate results. In a proportion of the cases which have recovered we have also been able to make further observations after the lapse of several years, owing to the fact that further surgical operation has been necessary, post-operative ventral herniæ having developed at the site where a tube or tubes had been left in for the establishment of drainage, or the patients have developed gall-stones or cholecystitis. The series of cases further demonstrates some variations in the clinical and pathological signs and symptoms which are worthy of record. In all, 15 cases have been treated by me during this period.

The term 'acute pancreatitis' comprises several pathological conditions but in the main the clinical symptoms exhibited are similar and characteristic. Acute catarrhal pancreatitis is described, but, from my experience, if it does not pass into one of the three forms hereinafter mentioned, it is very difficult for the clinician to diagnose it with certainty.

The forms of acute pancreatitis which come under the observation of the surgeon are three: (1) *Acute hæmorrhagic pancreatitis*, (2) *Acute gangrenous pancreatitis*, (3) *Acute suppurative pancreatitis*. The third variety however would appear to be a later stage localized and very violent of the first. In its most acute form the affection is one of the most serious diseases which the surgeon is called upon to treat, and if a reasonable amount of success is to be obtained it is very essential that early diagnosis be made and immediate treatment carried out.

Symptoms —

1 *Acute Abdominal Pain*—Pain, referred to the epigastrium or the adjacent portion of the abdomen may be so acute and sudden as to cause immediate collapse, and is usually the first symptom noticed. In *Case 10* the patient—a clerk employed in the City—came up by train in order to attend his ordinary occupation and as he was walking from the station to his office he was suddenly seized with violent abdominal pain (which he referred to the epigastrium) which caused him to collapse on the pavement after clinging for a brief period to some adjacent railings, whilst in *Case 6* a lady attended a garden party one afternoon and when walking home was seized as she was crossing a lawn with violent abdominal pain referred to the epigastrium and right hypochondrium. She collapsed and had to be taken home in a vehicle. These two cases represent the most acute form of onset, in others the abdominal pain had not such an acute onset but in all it was severe. Within a few hours of onset pruritis are almost invariably felt in the upper

region, either on one or both sides. This spread of the pain to the lumbar region when taken into consideration with other clinical signs and symptoms mentioned later is almost pathognomonic of the affection.

2 *Vomiting*—This is a fairly constant symptom during the onset of the disease, but it is not invariable and there may be merely nausea. The ejecta are the contents of the stomach and bile, I have not seen any patients in whom blood has been met with although it is stated by some observers that this does occur.

3 *Rigidity of the Abdominal Wall*—This is not usually a marked sign during the onset of the disease although deep-seated tenderness with slight overlying rigidity may be elicited on pressure in the epigastric region. The majority of patients who are the subjects of acute pancreatitis are very obese consequently the detection of deep-seated tenderness is not always easy. When the disease is well established and septic peritonitis has developed then there may be general abdominal rigidity but this is not constant. In Case 4 in which the disease was of five days' duration, the abdomen was quite soft, although the patient was almost moribund from toxæmia and the general peritoneal cavity contained a considerable quantity of blood-stained serous fluid and there were extensive areas of fat necrosis.

4 *Temperature and Pulse*—Immediately after the onset the pulse is rapid and weak, but later it becomes fuller, especially when the temperature is raised. The temperature is at first subnormal and then raised, but generally not more than 101° or 102° .

5 *Cyanosis and Jaundice*—In the very acute cases cyanosis of the face and extremities is generally a characteristic sign. Some observers have also detected it in the abdominal wall, but I have not met with it in this region. When present and associated with acute abdominal pain most marked in the lumbar region it may be looked upon as almost pathognomonic of acute hemorrhagic pancreatitis. In the less acute cases a slight icteric tinge of the skin and membranes may be noticed, and bile detected in the urine. There may also be dyspnoea or difficulty in breathing. This combination of cyanosis and difficulty in breathing was very marked in Case 13.

6 *Localized Abdominal Swelling*—Occasionally a distinct swelling can be felt in the epigastric region lying transversely and in the normal position of the pancreas, with normal stomaich resonance in front of it, whenever the patient suffers from gastrioptosis this swelling can be felt immediately behind the anterior abdominal wall and below the liver. Owing, however to the general obesity of the patients, it is difficult to detect any definite swelling, but if they happen to be sparsely covered it may be felt, as in Cases 5, 8, and 9. In the less acute cases which have become suppurative, a swelling can almost invariably be detected on palpation.

7 *Diastase in the Urine*—Normal urine contains 10 to 20 units of an amylolytic ferment—diastase. In disease of the pancreas associated with pancreatic insufficiency, this diastase may amount to 100 or 200 units, or even more. Many cases of acute pancreatitis reveal this increase of diastase but in the very acute cases sufficient time has not always elapsed between the onset of the disease and the examination of the urine to enable it to be manifest. This is especially the case in the acute hemorrhagic type, the acute

gangrenous and suppurative types almost invariably show excess of diastase (*Cases 8, 13, and 15*)

8 Adrenalin Mydriasis Test—A test known as Loewe's adrenalin mydriasis test is considered by some observers to be of value in the diagnosis of pancreatic disease. The test is carried out by dropping two drops of 1-1000 adrenalin solution into one conjunctival sac, a proceeding which is repeated after an interval of five minutes. If at the expiration of thirty minutes dilatation of the pupil is noticed, then the test is considered positive and pathognomonic of pancreatic disease. The other eye is used as a control in the observation. Our experience in the series of cases quoted later is that the test has been positive in three out of four cases.

9 Glycosuria—Sugar in the urine has been detected in a small number of cases of acute pancreatitis, but it is far from constant, and when occurring is often transient. One patient whom I saw with the late Mr. Lockwood was a man of 29 who suffered from acute abdominal pain located above the umbilicus. He was at first considered to have acute appendicitis, but a large amount of sugar was detected in the urine, and on this account acute pancreatitis was suspected. Since this quickly disappeared, the diagnosis of appendicitis was reverted to, and an operation performed for the removal of the appendix. This was found to be normal. Blood-stained fluid was present in the peritoneal cavity, and the cause of the symptoms was found to be acute hæmorrhagic pancreatitis. This patient survived the operation for a few days only but sugar did not reappear in the urine.

The three preceding signs—diastase in the urine, adrenalin mydriasis, and glycosuria—are fairly constant in chronic pancreatitis, and are of considerable importance in making a diagnosis, but in acute pancreatitis, especially the fulminating forms, their absence cannot be considered as contra-indicating the existence of pancreatic disease, and their presence merely confirms the clinical diagnosis from the other signs and symptoms. Cammidge's pancreatic test, in my experience, is of no value in the diagnosis of acute pancreatitis.

Diagnosis—The acute abdominal affections which in some respects show various signs and symptoms comparable with those of acute pancreatitis are (1) *Acute appendicitis*, (2) *Perforation of a gastric or duodenal ulcer*, (3) *Biliary colic*, (4) *Acute intestinal obstruction*, such as that met with in volvulus, strangulation by a fibrous band, Meckel's diverticulum or an internal hernia.

Careful attention to the position of the pain and its mode of onset and its tendency to become marked in the lumbar region, comparative softness of the abdomen in the early stages, toxæmia and cyanosis, increased diastase in the urine, occasional glycosuria and slight jaundice or icteric tinge will usually enable the clinician to make a diagnosis. Cases, however, occur in which the signs and symptoms are not sufficiently pronounced at first or their character has been altered by the previous administration of morphine so that an exploratory operation is necessary before a correct diagnosis can be made.

Course of the Disease—Unless treated by prompt surgical measures acute pancreatitis is rapidly fatal, from two to five or six days being the

ordinary duration. In some cases an abscess may form in which event the duration is longer (*Cases 8 and 9*)

Treatment.—Whenever acute pancreatitis is either diagnosed or from the signs and symptoms reasonably suspected immediate operation should be recommended. The sooner this can be done after the onset of the affection the greater are the chances of recovery. The greater sac of the peritoneum

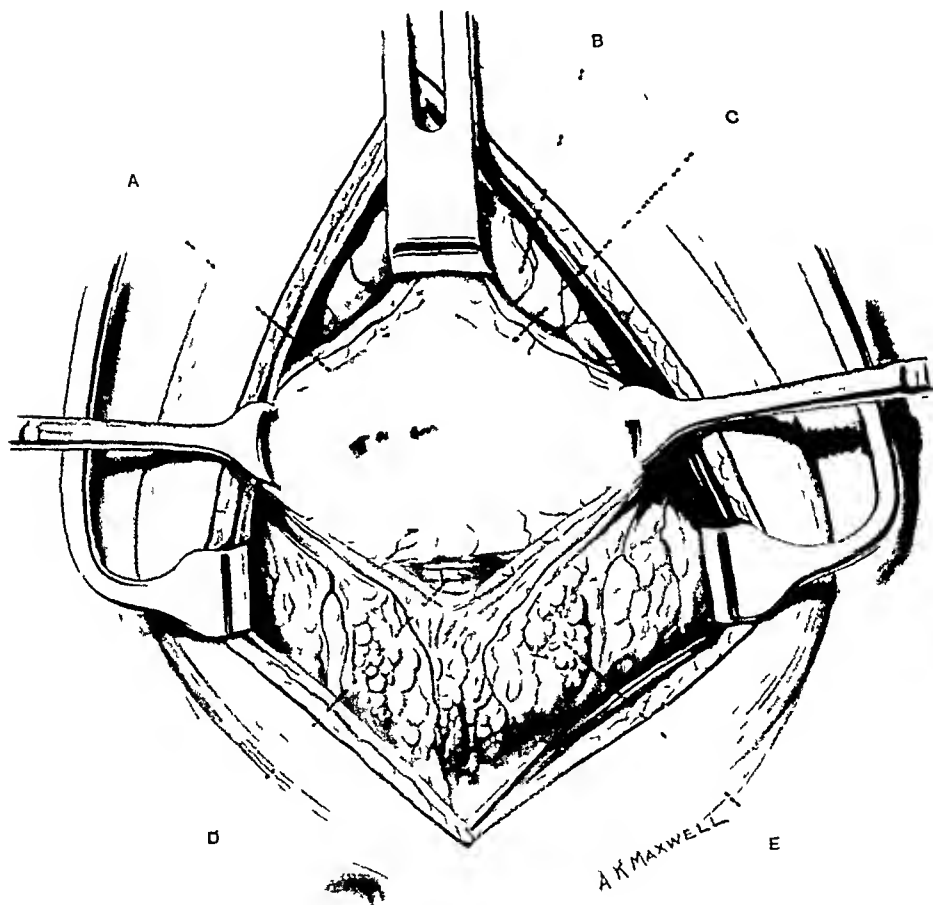


FIG. 282.—Acute pancreatitis. A Hemorrhagic pancreas B Stomach C Gastrocolic omentum incised vertically D Lesser sac and blood stained fluid therein E Area of fat necrosis

is opened by an incision a little to the right of the medial line, commencing in the epigastric region and extending below the umbilicus. Since most of the patients are obese, an incision of 5 inches (12 cm) or more is generally necessary. Usually, on opening the cavity of the peritoneum, blood-stained fluid will be met with, but in early cases this is limited to the lesser sac, in which case red-coloured fluid will be visible in the great omentum immediately

below the greater curvature of the stomach. This appearance is well shown in *Fig 282*. In addition white areas of fat necrosis may be seen in the omentum and exposed peritoneum. When dealing with a case of doubtful diagnosis the presence of areas of fat necrosis and blood-stained serous fluid in the peritoneal cavity may be regarded as pathognomonic of acute pancreatitis. Complete exposure of the pancreas is usually effected by dividing the anterior two layers of the great omentum immediately below the greater curvature of the stomach, separating the margins of the incision, and lifting up the stomach towards the lower margin of the thorax. The appearances then presented are shown in the illustration. After exposure free incisions should be made into the swollen pancreas in a direction parallel to its long axis, and all blood clots and serous fluid removed by sponging. Large drainage tubes are passed down to the incised area, and the region of the pancreas is packed with a wide and long strip of absorbent gauze. The margins of the incision in the great omentum should next be sutured to the margins of the incision in the parietal peritoneum and the remainder of the incision in the abdominal wall closed. On account of the necessity of the establishment of free drainage, post-operative haemorrhage is liable to occur after the operation wound has healed. This however can readily be cured by a secondary operation (*Cases 1, 7, and 12*).

After-treatment --

Drainage—It must be remembered that during an attack of acute pancreatitis large portions of the organ are destroyed and that sloughs continue to separate for many weeks after the original operation. In *Case 1* sloughs were discharged for nine months. In *Case 15* the tubes were removed three weeks after operation, and a second attack of acute pancreatitis occurred two days later. A second operation was performed, and again the tubes were removed after two weeks only to be succeeded the next day by severe epigastric pain and vomiting. The tubes were again introduced into the lesser sac and several small pancreatic sloughs evacuated.

Dressing—The material discharged from the wound generally contains activated pancreatic juice, which causes severe excoriation of the surrounding skin. This may be prevented or minimized by the use of a heavy mineral oil—e.g., paraffinum molle. Ointments with a laid base of course, are digested by the pancreatic fluid.

Feeding—After acute pancreatitis the patients waste rapidly owing largely to lack of pancreatic digestion. Feeds must be frequent and in the early stages should all be pancretized. Until the diastase content of the urine has fallen to normal fats should be almost entirely withheld and then should be given sparingly and never allowed to accumulate in the stools.

Morbid Anatomy—In the first stage of acute pancreatitis the head of the gland becomes swollen and pink and its peritoneal surface shiny and tense. The swelling rapidly spreads along the body of the organ until two thirds or more may be involved. A little serous peritoneal exudate may be observed but fat necrosis is not found at this stage. The next stages occur very rapidly—first softening in the region of the head and then sudden hemorrhage plunging up the gland tissue and causing a large dark swelling

(see Fig 282), the blood may infiltrate between the layers of the transverse mesocolon into the root of the mesentery or into the retroperitoneal tissues of the posterior abdominal wall. In some cases the hæmorrhage remains localized, in others it bursts through the serous covering into the lesser or greater sac or both, producing the most acute symptoms of 'perforation of the pancreas'. In the hæmorrhagic stage fat necrosis is found. With the progress of the disease pancreatic juice is mixed with the blood producing alteration in the character of the exudate which becomes chocolate-coloured and often foul-smelling from secondary infection. General peritonitis supervenes, and unless drainage is established death occurs.

Large areas of the pancreas become necrosed and are extruded as putty-like sloughs. occasionally the whole of the gland has been sequestered as a slough either through a drainage wound or the rectum (Dever and Chan). In cases where the hæmorrhage remains confined in the peritoneal capsule of the pancreas (gangrenous pancreatitis) secondary infection occurs later, with the production of a localized abscess (suppurative pancreatitis). The disease then runs a much more chronic course.

It is our belief that all cases of acute pancreatitis are due to infection therefore the old theories of pancreatic apoplexy will not be considered in this paper. The infecting organism is nearly always the *Bacillus coli communis* (Case 8), but occasionally streptococci may also be found. It is not unusual to find that the material removed at operation is sterile (Case 11), probably because the activated pancreatic ferments have killed off the bacteria. There are several routes by which infection may reach the pancreas, and it seems likely that more than one of them may be used by the organisms in different cases. There seems little doubt, however, that the primary source of infection is generally the gall-bladder or the duodenum. In the main, infection is spread from these organs to the pancreas by the lymph vessels or by the pancreatic or common bile duct. The majority of the efferent lymph vessels of the gall-bladder pass to a lymph gland situated at the junction of the neck of the organ with the cystic duct, they then pursue a course down the common bile-duct, interrupted by several lymph nodes, finally reaching the back of the pancreas before termination in the anterior aortic group of lymph glands.

In two-thirds of the cases the common bile-duct is embedded in the substance of the head of the pancreas, and the efferent lymph vessels of the gall-bladder accompany it. In this position the vessels are brought into intimate relation with the lymph vessels of the head of the pancreas and in fact have many and free communications with them. Infection therefore brought from the gall-bladder may readily cause a pancreatic lymphangitis, the starting-point of acute pancreatitis.

The lymph vessels of the first and second part of the duodenum have a similar but less intimate connection with those of the head of the pancreas.

Retrograde infection along the pancreatic ducts by bile is probably a less common cause than lymphatic infection, but its occurrence has been definitely proved. In Case 15 an illustrated plate of which accompanied our article in Gask and Wilson's *Surgery*, 1920, three gall-stones were demonstrated impacted in the ampulla of Vater. the main pancreatic ducts and much of the glandular

tissue were deeply stained by bile. On examining a microscopic section of the organ it was found that even the minute ducts and acini contained bile pigment. Only in one case, however, have we found definite evidence of obstruction in the ampulla of Vater, or of regurgitation of bile, although jaundice has been present in seven cases. It is possible that spasm of the muscle surrounding the ampulla (Oddi's sphincter) may cause a transient regurgitation of infected bile which is not sufficient in quantity to stain the body of the pancreas.

We have no case to prove that infection ever occurs directly from the duodenum along the pancreatic ducts. Our work tends to show that the duodenal contents are sterile, or nearly so, and that micro-organisms never exist there in sufficient numbers to make invasion of the pancreas likely or formidable.

Normally the pancreatic juice is not activated until it reaches the intestine. If, however, trypsinogen be converted into trypsin in the ducts or substance of the organ, rapid destruction of tissue must be expected, producing a condition so like an acute gastric ulcer that Mayo has spoken of it as 'perforation of the pancreas'. Activation of trypsin within the gland is the predominant factor of acute hæmorrhagic pancreatitis. A number of reagents found in the body other than enterokinase can activate trypsinogen, chief amongst them being blood, infected bile, degenerate leucocytes and certain bacterial toxins.

Archibald, supported by Dever, is satisfied with the theory of retrojection of bile consequent upon spasm of the sphincter of the ampulla of Vater as the cause of the onset of the disease. This theory, however, does not explain the fact that the destruction of the pancreas is sometimes patchy, with isolated areas of sound pancreatic tissue showing signs of inflammation or of bile staining. It seems to us more likely that the activating agent in the majority of cases is blood. The first step in an acute inflammatory condition is the congestion of the pancreas and the production of small hæmorrhages. The majority of these occur in the interstitial tissue, but some occurring in the alveoli activate pancreatic juice, and local auto-digestion begins which soon opens a small vessel providing more blood to activate the trypsinogen and a vicious circle is produced, quickly resulting in the destruction of large areas of tissue.

Fat Necrosis—Fat necrosis occurs in all cases of acute pancreatitis. It may be widely distributed over the peritoneum, but is most plentiful in the transverse colon, the root of the mesentery, and the great omentum. From its distribution its origin was held to be due to the local action of escaped pancreatic juice, and this view is still widely held, but in a few cases the change has been found in the pericardial fat and the extrapleural fat places which cannot possibly have been exposed to the direct action of the fluid. It seems therefore that the occurrence of fat necrosis may be attributed also to ferments liberated by the diseased pancreas and circulating in the blood. At autopsies we have made careful search in the fat of other regions—e.g., subsynovial—but have not found fat necrosis outside the abdomen and thorax.

SUMMARY OF CASES

Case	Age	Sex	PAIN		VOMITING	GLYCOSURIA	JAUNDICE	SOFT ABDOMEN	SWELLING	SUGAR	DIASIASTOL	TOTAL	GLYCOSURIA	PANCREATITIS	REMARKS
			ABDOMEN	LUMBAR REGION											
1	40	M	+	+	+	+	+	+	+	/	/	/	O	+	R
2	40	M	+	+	O	O	O	+	+	Not ex. Not ex. Later 0 Later 10			O	+	R
3	77	M	+	+	+	+	+	+	O	++	250	/	O	+	R
4	63	F	+	+	+	+	+	+	O	/	/	/	/	+	D
5	60	F	+	+	+	+	+	+	O	/	/	/	O	+	D
6	51	F	+	+	+	+	+	+	O	/	/	/	O	+	D
7	40	F	+	O	+	O	O	+	O	/	/	/	O	+	R
8	53	M	+	O	+	/	+	+	+	O	200	+	O	+	D
9	50	M	+	+	+	O	+	+	+	+	/	/	O	+	D
10	42	M	+	+	+	O	+	+	O	O	/	+	O	+	R
11	41	M	+	O	+	O	O	O	O	O	200	O	O	+	R
12	57	F	+	+	+	+	+	+	O	+	128	/	O	+	R
2nd attack	59	F	+	+	O	+	+	+	O	++	200	/	O	+	D
13	38	M	+	O	/	/	/	/	/	/	/	/	+	+	D
14	46	M	+	/	/	/	/	/	/	/	/	/	+	+	D
15	42	F	+	+	+	O	+	+	O	O	100	-	O	+	R

+ = Present O = Absent / = No examination made or recorded R = Recovered D = Died

LIST OF CASES

Case 1—March 25, 1911 Gentleman, age 40 After watching Varsity sports in a snow blizzard, returned home at 5.45 and took tea One hour later had pain in the small of the back radiating up to both shoulders This increased until 1.30 a.m., when it was relieved by drinking brandy and hot water

March 29 Similar pain, relieved by brandy

March 30 Awoke feeling well and hungry, good breakfast felt dull about 10.30, continued working, 11.15, vomited No nausea or retching

March 31 Felt better, noticed bile in urine Took sedlitz powder but bowels were not opened, 10.30, 'felt dull', 11.15 vomited, 11.25, first noticed yellow appearance of eyes and face, was seen by doctor and sent to bed, 3.45 severe abdominal pain commenced, 5.30, fainted From 10.40 pain increased steadily until morphia $\frac{1}{2}$ gr was administered and patient went to sleep

April 1 Dozed nearly all day Pain severe when conscious, great thirst

On examination, the patient was found to be a very fat man He was definitely jaundiced and slightly cyanosed The abdomen was soft and moved with respiration, but on palpation a swelling could be felt, starting in the epigastrium in the mid line and extending to the left The swelling was dull on percussion, the stomach resonance being made out below it Immediate operation was advised

OPERATION—An incision was made over the swelling just to the right of the mid-line On opening the general peritoneal cavity a reddish-blue swelling could be seen pushing forward the gastro-hepatic omentum and displacing the stomach downwards The gall-bladder and ducts were palpated and no stone was felt A transverse incision was then made through the small omentum, and the lesser sac found to be filled with blood-clots and pus, which were evacuated The pancreas was swollen and soft in places, and was incised in its long axis There were patches of fat necrosis in the transverse mesocolon A large drainage tube was passed down to the pancreas, and the abdominal wound partially closed

The patient's convalescence was slow Pancreatic sloughs continued to be discharged for nine months after the operation, but he ultimately made a complete recovery He again came under observation ten years later—in 1921—when he was operated upon for repair of a post-operative ventral hernia At this time he was a healthy man, with no evidence of pancreatic disease The urine contained 10 units of diastase and no sugar

Case 2—Gentleman age 40 For eight days had vague abdominal discomfort which was associated with indigestion and flatulence, and then was seized with an acute attack of abdominal pain of such severity that he fainted On examination he was seen to be a moderately fat man suffering from severe shock His face was pale and sweating, but there was no noticeable cyanosis Pain was referred to the epigastrium and the lumbar region The abdomen moved well on respiration, and was soft A transverse swelling could be made out, situated deeply in the abdomen behind the gastro-hepatic omentum The swelling did not move on respiration and was dull on percussion, the stomach resonance being identified below The temperature was subnormal, and the pulse 130 A diagnosis of acute pancreatitis was made and operation advised

OPERATION—An incision 4 in long was made in the mid-line in the epigastrium and the peritoneal cavity opened Patches of fat necrosis were noticed in the great and small omentum and in the transverse mesocolon The lesser sac was explored through the gastro-hepatic omentum, and found to contain a little blood-stained fluid The pancreas was very swollen, and appeared bluish beneath the peritoneum An incision was made through its serous covering, starting over the head and continued along the long axis of the organ to the left extremity of the swelling Much blood stained seropurulent material was evacuated, and some blood clots A large red rubber drainage tube was passed down to the pancreas through the small omentum and the abdomen closed

The patient made an uninterrupted recovery, but during convalescence several putty-like sloughs were discharged through the drainage tube A post-operative

ventral hernia was repaired in 1920. At this time the patient appeared perfectly well, and there was no evidence of any pancreatic disturbance. The urine contained no sugar and 10 units of diastase. At operation the pancreas felt normal but the lesser sac was not opened to inspect it.

Case 3—Gentleman, age 77. Was seized with acute abdominal pain referred to the epigastrium and lumbar regions. Vomiting was severe, but shock not a marked symptom. On the following day he was brought to London, and on examination found to be slightly jaundiced and definitely cyanosed. The abdomen moved on respiration and was soft, but no swelling could be felt. Temperature, 103°, pulse, 120, respiration, 30. Urine sugar, diastase, 250 units. A diagnosis of acute pancreatitis was made.

OPERATION—Operation was performed immediately. The abdomen was opened through a mid-line incision above the umbilicus, and patches of fat necrosis were noticed in the great omentum. The lesser sac was explored through an incision through the anterior two layers of the great omentum about three inches below the greater curvature of the stomach. A bluish swelling was seen in the position of the head and proximal portion of the body of the pancreas. This was incised along its longitudinal axis, and clots and blood-stained material were evacuated. No stones were palpated in the gall-bladder or bile-passages. The pancreas was drained through two rubber tubes, and the abdominal wall closed. Recovery was uneventful.

Case 4—Woman, age 63, very fat. Had had severe abdominal pain for three days which had been diagnosed as subacute appendicitis. On examination, she was deeply cyanosed and slightly jaundiced. The abdomen moved feebly with respiration, and was soft. The pulse was almost imperceptible. A diagnosis of acute pancreatitis was made, but she was too ill to stand operation, and died two hours later. A post-mortem examination showed acute hæmorrhagic pancreatitis involving the head and practically the whole body of the gland.

Case 5—Lady, age 60. Had had vague abdominal pains and constipation for three days, and had been treated for chronic intestinal obstruction. On the fourth day she was much worse, with very severe lumbar pain and intense vomiting.

On examination, she was found to be slightly cyanosed and slightly jaundiced. The abdomen moved feebly on respiration and was soft. There was marked tenderness above the umbilicus and in the lumbar region. The temperature was 101°, the pulse feeble and irregular.

A diagnosis of acute pancreatitis was made, and operation not advised because of the enfeebled condition of the patient. Later, after consultation with three other surgeons, the pancreas was rapidly explored and drained, but the patient did not rally, and died on the following day.

Case 6—Lady, age 54, very stout. Had had several attacks of abdominal pain and vomiting during the past few years which had been diagnosed as biliary colic. Whilst crossing a lawn at a garden party she was seized with violent abdominal pains and collapsed. She was taken to the house and seen early the following morning. She was a very fat woman—20 stone, was deeply cyanosed and slightly jaundiced. She had severe pain and tenderness above the umbilicus and in the lumbar region. The abdomen moved on respiration and was soft, but no swelling could be palpated through the fat. Temperature 99°, and pulse feeble and uncountable. A diagnosis of acute pancreatitis was made.

OPERATION—At 9 a.m. the abdomen was opened through a mid-line incision, and fat necrosis noted scattered throughout the subperitoneal fat. There was much blood-stained fluid in the greater and lesser peritoneal sacs. The pancreas was explored through the anterior two layers of the great omentum, and was found to be almost completely destroyed by extensive hæmorrhagic extravasation. A large red rubber drainage tube was introduced into the lesser sac and one into the greater sac, and the abdomen closed. The patient died on the following day.

Case 7—Lady, age 40 Had indefinite abdominal pain which gradually became more acute and localized in the right hypochondrium Vomiting became severe, but there was no cyanosis and no jaundice The abdomen moved slightly on respiration and there was resistance to pressure in the upper part, more pronounced on the right A diagnosis of biliary colic was made

OPERATION—The abdomen was opened through a vertical incision to the right of the mid-line When the peritoneum was opened fat necrosis was observed in the great omentum and the pancreas could be felt to be much swollen No gall stones could be palpated in the gall-bladder or biliary passages The lesser sac was explored through the anterior two layers of the great omentum, and a blue swelling was observed in the proximal part of the body of the pancreas This was incised in its long axis, and blood-clots and blood-stained fluid were evacuated A large red-rubber drainage tube was passed down to the diseased area of the pancreas, and the abdominal wall closed The patient made a good recovery, but later came up for repair of a post-operative ventral hernia The opportunity was taken to explore the pancreas which was apparently normal The urine examined at the time showed 10 units of diastase and no sugar

Case 8—Man, age 55, ventriloquist Admitted to St Bartholomew's on June 12, 1913, complaining of abdominal pain and vomiting For three weeks before admission patient had had very severe attacks of vomiting On June 10 he became worse and vomited incessantly The stools were pale in colour at first, and then for a week were 'very black, like congealed blood

On admission to the hospital he was a well-nourished man Tongue very heavily coated Chest, nothing abnormal discovered The abdomen moved well on respiration It was soft on palpation except in the right hypochondrium, where there was some tender resistance Over this area there was an impairment of the percussion note which was continuous with the liver dullness A lump could be felt in the epigastrium, but its limits could not be clearly defined It did not move on respiration The knee-jerks were absent Urine acid, albumin ++, blood 0, sugar 0 Loewe reaction +

OPERATION, June 14—Laparotomy, mid-line incision, and drainage of lesser sac No fat necrosis was seen and no gall stones were found The lesser sac was explored through the transverse mesocolon, and found to contain blood stained fluid The head and body of the pancreas were hard and enlarged to about the size of a Tangerine orange Its centre was deeply excavated, and extensive hemorrhage had taken place into it

PATHOLOGICAL REPORTS—Fluid from peritoneal cavity sterile Fluid from pancreas pure growth of *B coli* June 16 Urine diastase 200 units, no sugar, mobilin +, glyconomic acid + Cammidge's reaction negative after forty eight hours Fæces no excess of fat Vomit acid, blood, bile Loewe's test, +

On June 21 several sloughs were washed out through the tube On June 24 patient collapsed suddenly, and died the next day

POST-MORTEM—Lesser sac contained masses of necrotic tissue and pus A large portion of the pancreas was apparently normal, and on section showed a round celled infiltration Fat necrosis was very limited, the few spots being on the great omentum and in the iliac fossæ No signs of cholecystitis or gall stones

Case 9—Man, age 50 street salesman Admitted to St Bartholomew's Jan 26, 1915 On Dec 18, 1914, patient was thrown off a lorry, injuring his head and abdomen, and was unconscious for about half an hour The accident was followed by severe pain in the abdomen and back, and morning vomiting He resumed work in three days and was fairly well until Jan 10 1915, when he first noticed a swelling in the epigastrie and umbilical regions On Jan 16 he had a large excess of alcohol, on the morning of Jan 17 he drank a tumbler of cold water and was immediately seized with a gripping pain around the umbilicus which doubled him up The swelling was also noticed to have increased in size Micturition was suspended for three days, and followed by hematuria On Jan 24 he had a second attack of pain He had been a heavy drinker for ten years He had dysentery in 1891 and lumbago in 1904 There was no history of jaundice

On admission to hospital he was a heavily built man, his face was puffy and slightly cyanosed. The abdomen was very soft and distended, and moved well on respiration. A large mass was felt in the abdomen extending from the ensiform cartilage to the umbilicus which was tender and non-fluctuating. The liver dullness was decreased, and free fluid demonstrated in the abdomen. Red blood-cells, 4,640,000, white blood-cells, 32,800. Urine contained sugar. A diagnosis was made of acute hæmorrhagic pancreatitis.

OPERATION, Jun 26—Pancreatotomy and drainage. A mid-line incision was made, and patches of fat necrosis were noticed in the great omentum. The lesser sac was explored through the gastrocolic omentum. Two swellings were felt, one over the head of the pancreas and one extending from the left side of the body of the pancreas towards the spleen. They contained much blood-stained serous fluid, which was evacuated. A large red-rubber tube was used to drain the lesser sac.

After the operation the wound continued to discharge blood-stained serous fluid which subsequently became infected with coliform bacilli and streptococci. Several sloughs of pancreatic tissue were extruded at different times. The patient wasted gradually, and died on March 4, 1915.

POST-MORTEM—Fat necrosis was well marked. The retroperitoneal tissues were suppurating profusely, and in the neighbourhood of the attachment of the mesentery were represented by large putty-like sloughs, apparently originating from the pancreas. The liver was very fatty and the gall-bladder large. No gall-stones were found.

Case 10—Man, age 42, garden constable. Admitted to St Bartholomew's on Aug 6, 1915. On Aug 2, 1915, when patient was on duty he was seized with an attack of abdominal pain which caused him to fall down and to vomit. The pain, which was most severe in the epigastrium and lumbar regions but also felt in the lower abdomen, and the vomiting, persisted until his admission to hospital. Similar attacks of pain and vomiting were experienced in 1907 and 1909, these lasted about ten days.

The patient weighed 20 stone at the time of his admission to hospital. There was marked jaundice of the conjunctiva. The tongue was furred, and the lips were somewhat cyanotic. Temperature, 100.2° pulse, 104, respiration, 24. The abdomen was very thickly covered with fat, and moved fairly well on respiration. There was tenderness and rigidity over the epigastrium. No swelling palpable per abdomen. White blood cells, 20,000. Loewe test, +. Urine bile, +, acetone, 0, sugar, 0, albumin, +. This case was diagnosed as acute hæmorrhagic pancreatitis.

OPERATION, Aug 7, 1915—Pancreatotomy and drainage. A mid-line incision was made above the umbilicus, and the peritoneal cavity was found to contain much blood stained fluid. There was well-marked fat necrosis in the omentum. The lesser sac was opened through the gastrocolic omentum, and a large collection of brown fluid mingled with sloughs found. There was induration of the head of the pancreas. Gall-stones were present in the gall-bladder. The patient died ten hours after the operation.

POST-MORTEM—Examination showed acute hæmorrhagic pancreatitis with general peritonitis. Anaerobes and *B. coli* were cultured from the pus.

Case 11—Man, age 44, engineer. Admitted to St Bartholomew's, Jan 6, 1917. Had suffered from abdominal pain since 1913. In January, 1916, he had a sudden attack of pain in the right side of the abdomen, with vomiting. In June, 1916, he had a similar attack. On Jan 4, 1917, he awoke with severe pain in the right side of the abdomen which caused him to double up and vomit. The pain continued until he was admitted to hospital two days later. The patient, who had previously been given morphine by his doctor, walked into the ward. Temperature, 99°, pulse, 130. He was a well-nourished man and looked healthy. There was no cyanosis. The abdomen was distended and pendulous, and moved on respiration. There was general tenderness and some resistance in the right iliac fossa. Per rectum nothing abnormal could be discovered. Urine was normal. A diagnosis of sub-acute appendicitis was made.

OPERATION, Jan 8 —Through a gridiron incision the appendix was examined and removed. It was found to be slightly inflamed, but not sufficiently to cause the symptoms. A second incision was made half an inch to the right of the mid line below the umbilicus. The lesser sac was found to be filled with blood. The pancreas was swollen and soft, and its anterior surface was incised longitudinally and the sac drained. The gall-bladder and ducts were normal. An examination of the fluid removed showed the presence of blood but no organisms. The patient made an uninterrupted recovery, and was discharged from hospital on Feb 7, 1917. On Jan 29 the diastase of the urine was 32 units. No sugar was found in the urine at any time, and Loewe's test was not applied.

May 1923 Patient again seen, suffering from an attack of gout.

Case 12 —Woman, age 57, cook. Admitted on June 16, 1915. Had long indigestion and flatulence for years, and often had epigastric pain and vomiting. On June 15 at 10.30 a.m. she experienced a very severe attack of epigastric pain and vomited several times. The attack continued until her admission to hospital. As a child she had small-pox and typhoid fever. On admission she was seen to be very obese and drowsy, her complexion was cyanotic. The tongue was heavily coated, the abdomen was very full and pendulous and moved slightly on respiration. There was marked tenderness in the lower epigastric region, and some tenderness in both lumbar and umbilicus regions. There was shifting dullness in the flanks, and a fluid thrill was obtained through the lower abdomen. The urine contained no sugar or blood, but a slight amount of diacetic acid and 200 units diastase. Loewe's test was negative. A diagnosis of acute hæmorrhagic pancreatitis was then made.

OPERATION —On June 18 a laparotomy was performed. Fat necrosis was found in the extraperitoneal fat, and the lesser sac was filled with a blood-stained fluid which was sterile. The pancreas was sloughing and full of blood clots. The lesser sac was drained with a large red-rubber tube. Recovery was slow, and a tube had to be left in until Aug 31 owing to continually discharging sloughs from the pancreas. Patient had periodic attacks of abdominal pain, chiefly on the left side, these gradually subsided. The wound was completely healed when the patient was discharged on Sept 8. At no time during the period she was in hospital had sugar been found in the urine, Loewe's test was negative on June 22, 1915, and on June 24 the diastase of the urine was 100 units.

SUBSEQUENT HISTORY —Well until February, 1916, when she had a similar attack of pain and vomiting which lasted for a few days. Further attacks were experienced in June 1916, November, 1916, and March 1917. In May, 1917, she was re-admitted to hospital for operation for post-operative ventral hernia. On May 19 an examination of the urine showed 0.3 per cent of sugar and 8 units of diastase. On May 25 1917 she had another attack of acute hæmorrhagic pancreatitis. Laparotomy was performed by Mr. Blakeway, and a little blood-stained serum found in the peritoneal cavity. This was mopped out and the abdomen closed. Culture from the blood gave no growth. On May 31 1917 the urine contained a trace of sugar and 128 units of diastase. She was discharged cured on June 17.

Case 13 —Man, age 38, cook. Admitted to St Bartholomew's, July 15 1912, complaining of severe abdominal pain. On July 15, after drinking an iced lemonade the patient was seized with very acute abdominal pain referred to the region of the umbilicus, and was brought up to the hospital. He was a very fat man, and on admission was cyanosed and suffering from acute dyspnoea. The abdomen was soft and moved on respiration, and no tumour could be felt. The urine contained a large amount of sugar and 200 units of diastase. Cammidge's test was negative.

Operation was not thought advisable, and the patient was transferred to a medical ward, where he died on July 22 1912.

POST-MORTEM —The pancreas was found to be soft and hæmorrhagic. The liver weighed 100 oz. and showed well-marked fatty emphysema. The gall bladder and ducts were normal. There were large areas of fat necrosis in the peritoneum and the kidneys showed acute nephritis.

Case 14—Man, age 46 Admitted on April 19, 1911 complaining of severe abdominal pain Laparotomy was performed immediately and the pancreas drained The patient died a few hours later

POST-MORTEM—Examination showed the body of a very fat male There was blood stained fluid in the peritoneal cavity, and extravasation of blood behind the peritoneum There were patches of fat necrosis amongst the retroperitoneal fat The pancreas was swollen and completely hæmorrhagic and is preserved in the museum at St Bartholomew's The gall-bladder was shrunk and contained several small calculi The stomach showed acute dilatation No organism could be grown from the pancreas or gall-bladder The heart's blood and peritoneal fluid contained anaerobes

Case 15—Lady, age 42 Whilst on holiday was seized with severe epigastric pain and vomiting She was seen by a local doctor and diagnosed as perforated gastric ulcer, and sent by ambulance to London

Aug 4, 1923 On examination, the signs were found to be rather obscured by morphia The patient was fat, and there were no cyanosis and no jaundice The abdomen was tender in the lower epigastrium and to the right of the umbilicus, but was fairly soft and moved on respiration There was no tenderness in the lumbar region The diagnosis was ? appendicitis, ? cholecystitis, ? acute pancreatitis

OPERATION—The abdomen was opened through the right rectus muscle The appendix and gall-bladder were normal, but blood-stained fluid was seen between the layers of the great omentum The lesser sac was then opened below the stomach and blood stained serous fluid evacuated The head of the pancreas was swollen and soft The pancreas was incised in its long axis and two large drainage tubes were inserted to drain the lesser sac No fat necrosis was observed at this stage The fluid from the lesser sac gave a pure growth of streptococci on culture, and the urine showed a diastase content of 100 units The tubes were removed on Aug 19

On Aug 25 at 2 p.m. the patient had severe epigastric and lumbar pain, accompanied by vomiting, and was given morphia $\frac{1}{4}$ gr At 5 p.m. when examined she said she felt very well There were no nausea and no cyanosis Temperature, 98.4° pulse, 80 The abdomen moved well on respiration, and there was only slight tenderness in the epigastric and lumbar regions

Aug 26, 4 a.m. The pain recurred with greater severity, the temperature dropped to 96° , and the pulse rose to 100 She was sweating and collapsed There was a slight icteric tinge in the conjunctiva, but no cyanosis The abdomen moved well and was soft but there was great tenderness above the umbilicus and to the left of the second lumbar vertebra It was decided to operate

SECOND OPERATION—The abdomen was opened through a mid-line incision extending downwards from the xiphisternum The gall-bladder and ducts were normal The lesser sac was opened through the anterior two layers of the great omentum, and a little blood-stained fluid and a few small pancreatic sloughs were evacuated There were a few spots of fat necrosis in the transverse mesocolon The pancreas was swollen throughout its length, and one soft spot was found about the middle of the body The organ was incised in its long axis and a large drainage tube inserted The opening in the great omentum was stitched to the parietal peritoneum, and the remainder of the abdominal wound closed

For three days following the operation the patient had occasional severe attacks of abdominal pain which lasted two or three minutes each On Aug 29 the diastase content of the urine was 100 units, and on Sept 3 it had fallen to 10 units On Sept 8 the tube came out On Sept 9 there was severe nausea and some epigastric pain An anæsthetic was administered and the large tube reinserted into the lesser sac and a few small pancreatic sloughs were removed This patient made a good recovery

Case 16—(This is an additional case which is still under observation, and is added as it demonstrates some points referred to) Woman age 46, housewife admitted to St Bartholomew's, Nov 8 1923 complaining of abdominal pain Had suffered from flatulence for years, and for the last two years had been subject to severe

attacks of pain in the right hypochondrium with vomiting and slight jaundice. These attacks recurred every two or three months and lasted for three to five days. On Nov 3, 1923, at 4.0 a.m. she was seized with severe pain in the right hypochondrium and epigastrium, having one hour previously vomited bile stained fluid. The pain persisted intermittently until admission, five days later.

On examination, the patient was seen to be a stout woman with a somewhat dusky complexion, but no cyanosis of lips or cheeks. The conjunctivæ were slightly yellow and the tongue covered with moist white fur. Temperature 100°, pulse 100, respiration 26. The abdomen was very well covered and moved well on palpation. There was slight tenderness in the right hypochondrium but no tenderness in the right iliac fossa, no rigidity of the right rectus muscle, and no swelling palpable. The knee-jerks were present and there was no œdema of the legs. The urine was dark yellow, S.G. 1020, acid, bile pigments present, no albumin and no sugar, urinary diastase, 50 units. White blood-count, 17,000 per c.mm.

After admission to hospital the patient complained of a pricking pain in the left hypochondrium on deep inspiration. There was no vomiting, and apart from the pain on inspiration she was fairly comfortable. On Nov 11, some pleuritic friction sounds were heard at the base of the left lung in the mid-axillary line. On the same day the patient passed per anum a faceted pure cholesterol gall stone one quarter of an inch in diameter. The diagnosis was made of cholelithiasis with gall stones in the gall-bladder. On Nov 14, Loewe's test was applied and found to be negative. Urinary diastase, 100 units. W.B.C. 20,000. An additional diagnosis of subacute pancreatitis was now made and immediate operation recommended. During the period of observation (Nov 8 to Nov 16) the temperature varied from 99.5° to 100.5°, and the pulse from 98 to 105. The bowels were opened, there was no vomiting, and the urine was free from bile pigment after the second day.

OPERATION, Nov 16, 1923.—The abdomen was opened by a right supra-umbilical rectus incision. The peritoneal cavity was found to contain some blood-stained fluid, and numerous areas of fat necrosis were observed on the great omentum. The gall-bladder was enlarged and contained numerous stones. This was removed, and the cystic duct was ligatured close to its junction with the common bile duct; the latter duct contained no stones. The body and tail of the pancreas were found to be enlarged and indurated and projecting above a ptosed stomach. The gastro-hepatic omentum was divided and the body of the pancreas incised in its long axis, when a mass of black slough was removed. Some hæmorrhage from this area was controlled with gauze plugging, and a large drainage tube was inserted down to the space in the pancreas. The cut edges of the opening in the lesser omentum were sutured to the parietal peritoneum, and the wound closed in layers, catgut being used entirely for the buried sutures.

After the operation the temperature fell gradually to normal on Nov 23. Pulse, 88 to 100. The plugging was removed on Nov 19 and the wound dressed four-hourly for the first three days. There was free discharge of blood stained purulent material and greyish sloughs from the pancreas. By Nov 21 the urinary diastase fell to 50 units, but was 100 again on Nov 25 and Nov 28. On Nov 26 the W.B.C. had fallen to 10,000. The free discharge of thick purulent material and greyish sloughs still continuing the wound is irrigated twice daily.

Dec 1. Progress continued, but drainage tube still in.

FRACTURE OF THE FEMUR A CLINICAL STUDY

BY R. HAMILTON RUSSELL, MELBOURNE AUSTRALIA

THE man who invented the term 'simple fracture' has been called an unconscious humorist, and the quip derives some justification from the frequency with which closed fractures are found to present so much difficulty in their management as to require operative fixation of the fragments. All are agreed that the opening up of a simple fracture is a measure to be deplored, but all are not agreed as to the exact reasons which render such a serious step imperative. We hold that there is only one circumstance that can justify such a surgical procedure, that is, mechanical impediment to the reposition of the fragments. To put it concisely, the purpose of operation must only be to enable fragments to be brought into position, and operation is not justified when its purpose is merely to keep them there. During the last ten years the method I shall describe, and its guiding principles have been very thoroughly tested at the Alfred Hospital, Melbourne, and during the last two years at the Children's Hospital also.

I propose to examine first the problems presented by the simplest kind of simple fracture, in which there is no obstacle to the restoration of the fragments to their normal position, no maceration of the broken ends in soft tissues, no interposition of muscle. In such a case (and of such are the large majority) the fragments can be easily brought into good position and maintained there, and from its careful study principles will emerge that should be found of value in the treatment of all varieties of fracture involving the long bones.

Let us suppose a patient with fracture of the middle of the femoral shaft just admitted to hospital.

The Thigh is Shortened Why?—The shortening is caused by the tonic contraction of certain long muscles that are attached above to the pelvic bone, and traverse the entire length of the thigh to be inserted into the tibia and fibula (*Fig 283*). Of these there are two opposing sets, consisting (in the main) of the hamstrings and the rectus femoris. Hence the semidiagrammatic representation of these muscles alone in the figure, for the numerous muscles that are attached to the femur itself play little if any part in the production of shortening, and for the sake of clearness are omitted from the diagram.

Musculi tone (which must always be carefully distinguished in our minds from *muscular action*) is a physiological property of living muscle, which for practical purposes causes the muscles to behave like rubber bands slightly stretched. Then correct length is maintained by the length of the femur and is soon as the femur is broken they shorten and produce over-riding of the fragments. Here the analogy ends for rubber once released from its tension will have no further power of contraction whereas the tonic shortening of the

muscles will be progressive. Hence the excessive shortening, amounting to three or four inches, that almost invariably complicates an ununited fracture of the femur.

Our first aim, then, will be to pull out these muscles to their correct length, and when we have accomplished this we may be sure that every other structure in the thigh will be in its correct position, including the fragments. This does not mean 'exact anatomical reposition', which is neither necessary nor even, in my opinion, always desirable. I shall shortly allude to this later.

What must we Pull upon?—Clearly the tibia and fibula, seeing that the muscles are attached to them. We are going to use strapping and bandages for the extension, and we shall accordingly not carry them above the knee for reasons that are obvious. I think that the practice, which seems universal, of carrying the strapping up the thigh indicates some confusion in our mental picture of the object to be attained. Anxiety as regards the ligaments of the knee seems also to be felt, but this is quite needless, for the ligaments

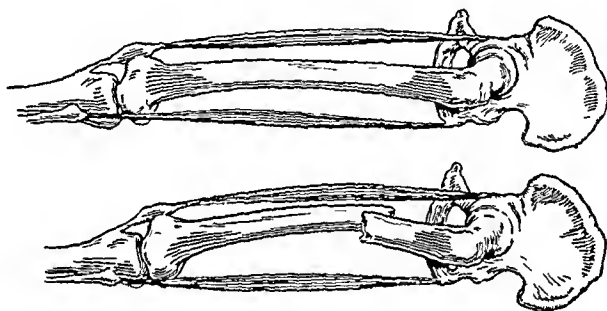


FIG. 283.—Illustrating the action of the long muscles in producing shortening.

of the knee, being attached to a fragment, cannot be subjected to stretching. The whole of the extending force will fall on the muscles, none at all on the ligaments, to convince ourselves of this, we only have to reflect that if the muscles were severed at the seat of fracture the limb would drop off.

How must we Pull upon the Tibia and Fibula?—If we merely attach a weight to the leg to pull out the thigh muscles, it is obvious that the leg and thigh will have to be in a straight line, or the thigh muscles cannot be extended. But this will never do, for one among several reasons, it would be intolerably uncomfortable, and perfect comfort, as we shall see is the first essential requirement in any appliance for the treatment of a fracture. We must have the knee slightly bent, but the bending of the knee is incompatible with the necessary pull on the thigh muscles that are attached to the tibia and fibula.

In a difficulty of this kind I always advise my students to do this. First take hold of the fractured limb with both hands and bring it into perfect position. Holding it thus, study carefully the position and *direction* of the forces you are applying. Then see if you can devise some plan of incorporating similar forces in an apparatus of some kind. In the case of the fractured femur, how does the surgeon manipulate it in order to draw out the thigh

muscles? He will do it in the following way (*Fig 284*) Standing by the side of the bed he passes the left hand under the knee the right hand grasps the leg above the ankle. Now he gradually exerts a little power the right hand pulling horizontally towards the foot of the bed the left hand up towards the ceiling mostly but with a slight inclination footwards also. The direction of the forces being exerted by the surgeon's hands are indicated by the arrows in the picture. The limb will not come out to its proper length all at once but the patient will feel more comfortable and will instinctively know that his limb is being skilfully and properly handled.

The surgeon now reasons thus. I am sure that this is the right way to get the thigh out to its proper length if only the thigh muscles were quiescent, but they are not owing to the patient's apprehension and fever. Were I able to stand here doing this for a few hours or until he sleeps, then there

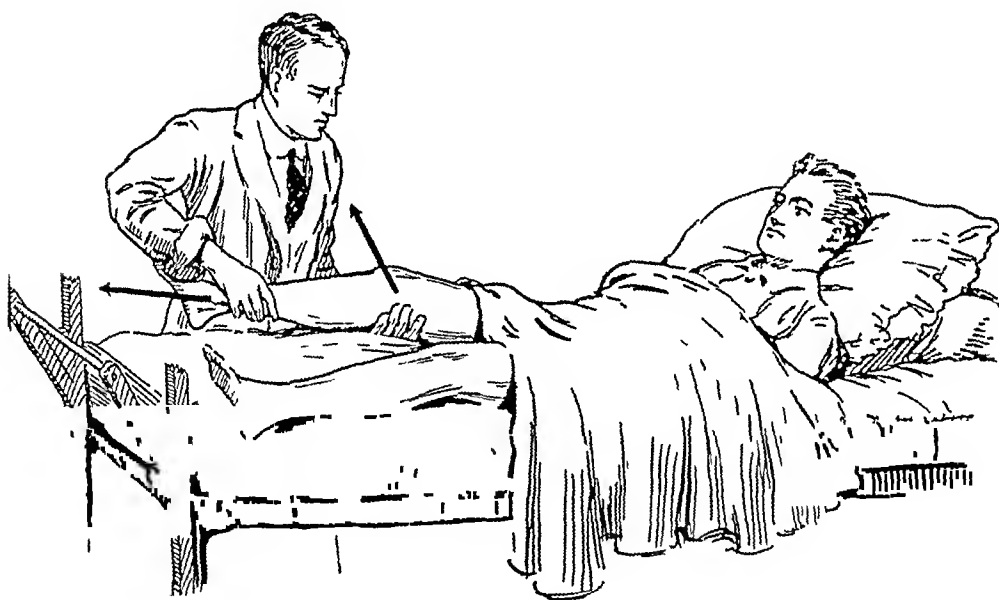


FIG 284—Manipulation to draw out the thigh muscles, the direction of the forces exerted being indicated by arrows

would be no difficulty, but obviously that is not possible. I must then devise some means of doing what I am now doing, something that will not tire, that will make the limb absolutely comfortable, and in that way favour the return of mental quietude.

The Apparatus—The arrangement shown in *Fig 285* was evolved in the way just described—a sling beneath the knee corresponding to the surgeon's left hand and horizontal traction on the leg corresponding to the surgeon's right hand. The arrangement provides that the pull on the leg shall be nominally double the upward lift at the knee, although actually somewhat modified by friction between pulleys and cord. The special apparatus required is as follows—

1. An ordinary overhead head-to-foot bar that can be shifted laterally as required. This can be fitted to the ordinary four-posted frame, but a

convenient way is to use merely two uprights at head and foot respectively, securely lashed to the bedstead

2 An arrangement to which may be attached a couple of pulleys beyond the foot of the bed. These pulleys should be in a horizontal line with the foot of the patient when the leg is lying horizontally on a pillow with the heel just clear of the bed. A convenient wooden or iron bracket can easily be made by the carpenter or the splint-maker

3 Four block-pulleys and suitable flexible cord

Application of the Apparatus—Usually an anæsthetic is not required, children have been known to sleep through the whole procedure

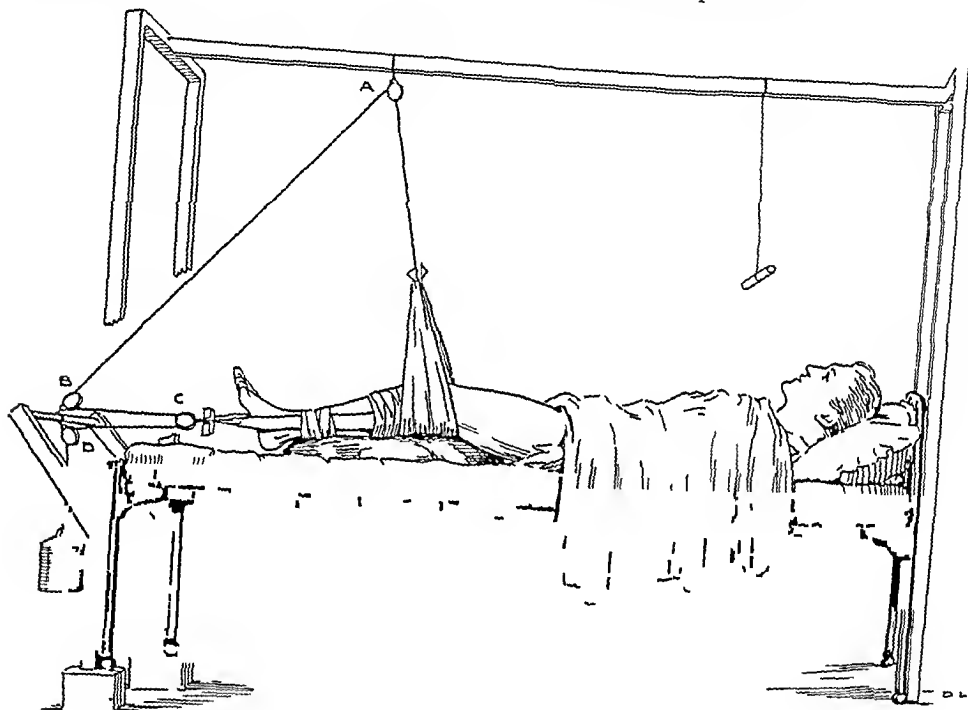


FIG. 285.—Showing the application of the sling

1 The leg having been prepared in the ordinary way is fitted with a spreader or stirrup close to the sole of the foot by a method similar to that used in 'Buck's extension', but with two important differences. (a) The strapping is not carried above the knee, (b) The spreader is provided with a pulley. A pattern of spreader we have found convenient is shown in Fig. 286, but its essential feature is that it must be long enough (5 in.) to deflect the strapping sufficiently to protect the malleoli from pressure. A light bandage over all from the roots of the toes to the knee, and the leg is ready.

2 The placing of the pulleys (see Figs. 285, 287). First, pulley A is tied to the overhead bar in such a position that a vertical dropped from it shall meet the leg well below the knee. Pulleys B and D are to be attached separately to the bar beyond the foot of the bed, pulley C is that attached to the spreader.

3 The knee-sling is now passed beneath the knee, which all this time has been lying comfortably on a pillow. The sling should be broad and soft, a soft rough towel suitably folded answers well. The ends of the sling are now securely tied together with the cord, which is then passed through the pulleys in the following order: (a) Up to pulley A, (b) To pulley B beyond the bed, (c) To pulley C on the spreader, (d) To pulley D (companion to B).

4 The surgeon now stands at the foot of the bed and slowly tightens up everything, and then the weight is attached. He next takes a soft pillow and adjusts it comfortably beneath the thigh to prevent gravitational sagging at the seat of fracture. Care must be taken that the pillow is really soft—a common fault is to have too hard and tightly-stuffed a pillow for this purpose. Next he looks to the heel, it must not be touching the bed, and he arranges another soft pillow beneath the leg and tendo Achillis to prevent it from doing so. And now the patient will be absolutely comfortable, and rest of both mind and body (including thigh muscles) will come to him. Finally, careful measurements are taken from the lower extremity of the anterior superior iliac spine to the upper margin of the patella on either side. Quite

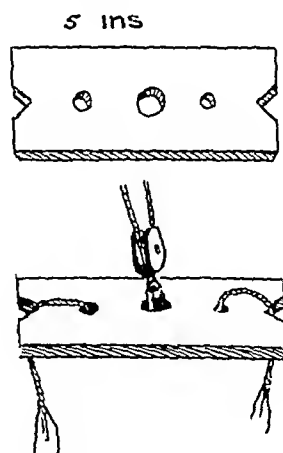


FIG 286 —The spreader

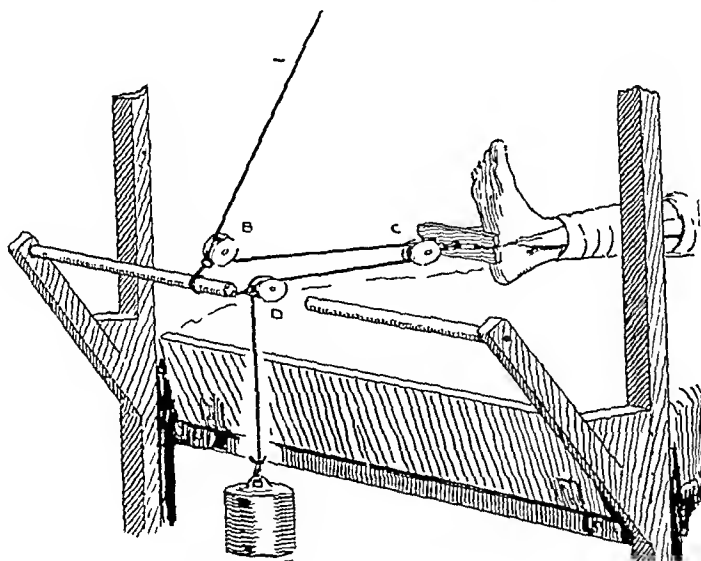


FIG 287 —Showing the arrangement of the pulleys

possibly especially if the manipulations have been leisurely and quiet, the length will already be nearly normal.

I notice that the first question usually asked is "What prevents the occurrence of eversion?" The knee-sling prevents it. Upward lifting of the

bent knee is the natural way of inverting the limb, when we wish to correct eversion instinctively we first bend the knee and then lift it upwards. The practical fact is that eversion gives no trouble.

The usual weight required for an adult is 8 lb, for infants and older children $\frac{1}{2}$ lb to 4 lb. These weights, it will be noted, are doubled by the pulley arrangement nominally, but in practice it would seem that there is considerable modification of the pull one way and another, and considerable latitude within the range of efficiency. The truth seems to be that really a very moderate pull is adequate provided that it is fairly constant and comfortable. At the end of the third week we always seek to reduce the weight.

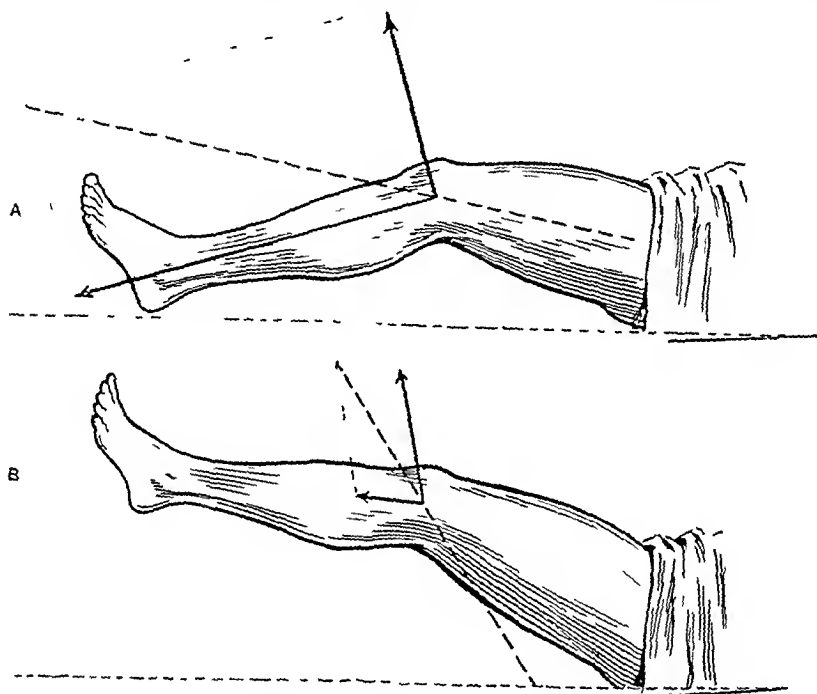


FIG. 288.—Mode of action of the two forces employed. A Correct position. B Faulty position.

The house surgeon's duty will be to take the measurements at least every morning and evening, and to inspect and adjust the pillows beneath the thigh and the leg so that there may be no backward sagging at the seat of fracture and the heel shall not be in contact with the bed. It is very little to require of him, but while it is very little and very easy, yet it is absolutely indispensable and must be faithfully given. The apparatus is far from being 'fool-proof', and cannot and will not look after itself.

Survey of What has been Done—The thigh muscles are being extended by a combination of two forces. We have seen why it is impossible to attain this object by a single force acting in a straight line. The accompanying diagram (Fig 288 A) will make evident the mode of action of the two forces employed. By constructing a parallelogram of forces on them it is seen that the resultant

will lie in the line of the thigh. Again, it will be noted that we have apparently taken no measures to secure and preserve good alignment, but bad alignment need never be seen in fractures treated in this way. Our teaching on this matter is very simple, and is somewhat at variance with traditional views, it may be stated thus —

1 *In a limb previously normal that is rendered perfectly comfortable in a natural position, muscular action is never the cause of displacement of fragments*

2 The causes of malposition of fragments are three in number, viz (a) Unnatural position and discomfort, (b) Action of gravity, (c) Splints. Some explanation is demanded, and we will examine these causes of trouble *separatim*.

a Unnatural Position and Discomfort—I believe that the most universal and the most unfortunate error that has hampered the treatment of fractures is the belief (under which I in common with others laboured for many years) that the limb must be placed in a certain position to meet the supposed requirements of a short proximal fragment that is being uncontrollably displaced by a certain muscle. I would instance the case of the iliopsoas muscle in fracture just below the lesser trochanter, and an equally good example taken from the upper extremity will be the visible displacement of one or other fragment of a broken humerus by the deltoid muscle. It would at first sight appear almost incontestably right in principle that the limb should be brought into alignment with the proximal fragment that is being pulled out of place in this way. I submit, however, that this is not so, for the following reason. The visible displacement, obviously caused by muscular action, is only a transient phenomenon, and will disappear as soon as the limb is put into a comfortable position and the surgeon's back is turned. So that when, with considerable pains and ingenuity, we have fixed the limb in an unnatural and uncomfortable position in deference to the proximal fragment, we shall find (or not find) that the proximal fragment ten minutes later will have changed its position altogether, that it and its muscles have assumed the position to which they are accustomed, and that the position we have assigned to the limb is altogether wrong. We ought to have disregarded the proximal fragment altogether, and placed the limb in a position that we know to be natural and comfortable, with the assurance that the position which is natural and comfortable for the entire limb will be equally so for the proximal fragment in common with the rest, and that such position will be that which it will assume.

Muscles are the creatures of habit and the slaves of custom. In a broken limb, every muscle and muscle fibre will co-operate in the endeavour to preserve the position to which it has always been habituated, and the last thing a muscle will do will be to abuse its liberty by displacing a fragment into an unnatural and unaccustomed position. Hence the remarkable circumstance that with our methods faulty alignment (other than that induced by gravity) is practically never seen, although great liberty is permitted.

It follows moreover that whether the fracture is in the upper, middle, or lower third the treatment is exactly the same, the position of the limb and the mode of extension is equally appropriate in all three cases.

The foregoing paragraph had scarcely been written when the following

curious illustration of its truth occurred. I saw in consultation a very stout woman who I was told had a supracondylar fracture of the femur in very good position. I gave a cursory glance at the singularly misleading skiasgram, and was well satisfied. It was not until she had been under treatment four or five weeks that I was informed to my amazement that a mistake had been made and that the fracture was not a supracondylar fracture but a subtrochanteric one. There were other circumstances, which need not be detailed that conspired to bring about this almost incredible incident, but the essential point is that the treatment we believed we were applying to the supracondylar fracture answered equally well for the subtrochanteric, and the result could not have been bettered.

b The Action of Gravity—This is the sole inescapable cause of angulation in the case of the femur, and is met and counteracted with the utmost care, as has been already described. It is a great advantage of our simple methods that the seat of fracture is always exposed to inspection and easy handling.

c Splints—The means of avoiding this source of difficulty is obvious. The Thomas splint, invaluable for many purposes, we never employ in the treatment of fracture of the femur, whether simple or compound.

To recapitulate. In fracture of the femur, given a method of pulling out the thigh muscles to their normal length by an appliance that is perfectly comfortable, nothing will then remain to be done except to counteract the effect of gravity at the seat of fracture.

This sounds almost too simple, it is, however, absolutely correct in principle, and it works well in practice when carried out with care. Experience has shown, however, that the practice presents difficulties and pitfalls that have to be known and recognized. What at first sight appear to be small details in the management of the cord and pulleys turn out to possess unexpected possibilities. I am always interested when asked by a house surgeon to see a case that he thinks is not satisfactory, it often ends in a valuable addition to the knowledge of us both. I will endeavour to give the substance of some of our bedside discussions with conciseness.

Examples—

Example 1 (Fig 288, B)—Patient has been in several days, but the length will not come right. The reason is at once obvious, the foot is too high, and thus I have found to be the most frequent of all errors for some reason. The heel should be almost, but not quite, touching the bed, whereas here it is several inches away from the mattress. We must lower the extension pulleys to the proper level, so that the leg becomes horizontal (*Fig 288, A*), and we must understand clearly the significance of this mistake and what had happened as a result of it. In the first place, a great part of the weight was employed in counteracting the weight of the limb, so that there was no power left for the purpose of extension of the thigh muscles, and they were not being extended at all, or very little. It is well, also, to reflect on what had happened to our parallelogram of forces, owing to the horizontal force having been so diminished, at the best the resultant (if there was a resultant) would have been directed almost vertically upwards and not in the line of the thigh at all. Now that the leg has been brought down to the horizontal

we shall find that the length will be distinctly improved at once. The patient will be more comfortable, and this is not merely a humane consideration but a physiological one, and of fundamental importance in the treatment of a fracture.

Example 2—The same difficulty as to length. Here, although the position of the leg and thigh is right, the fault lies in the direction of the upward pull on the knee. The pulley A is wrongly placed, being too far up towards the headstead-head, with the result that the upward pull is rather against the horizontal pull instead of co-operating with it. All we have to do will be to shift the position of pulley A footwards so as to change the direction of the lifting cord. The pull on the thigh can often be conveniently increased or diminished within narrow limits by merely altering the position of pulley A headwards or footwards as the case may be.

Example 3—The same difficulty as to length. The patient is a child, and will provide a study of great interest—the production of shortening by too heavy a weight. It is most likely to be seen in children, for reasons that are obvious, at the same time its teaching applies equally in the case of adults. In examination we find that the position of the leg and foot is horizontal, that the position of pulley A is right, and that our parallelogram of forces is consequently as it should be. But we notice that the child's pelvis is much pulled down on the injured side, so that it is lying very obliquely. This explains the shortening, and we now find that, through error, a weight of 5 lb is being used, which is a great deal too much for a child three or four years old. What has happened is that, by the pulling down of the pelvis, the limb has been brought into a position of extreme abduction. I do not think it is always realized that, while some abduction of the thigh in the treatment of fracture is favourably regarded, the amount permitted should be carefully limited, and should not be more than is present when a man stands with his heels three or four inches apart.

The means by which abduction of the limb causes over-riding of fragments and shortening must be explained at some length, the simplest, most practical and shortest way will be to study with the aid of the tape measure certain phenomena produced by abduction of the normal limb.

In the accompanying diagram (*Fig 289, A*) of the pelvic bone and the femur four things are to be noted—namely, the three points indicating the positions of the head of the femur, the tip of the great trochanter, and the anterior superior iliac spine, and the adductor magnus with its lowermost attachment to the adductor tubercle on the inner condyle. At first sight it would appear that the presence of the adductor magnus would render abduction of the limb impossible—it is only rendered possible by the presence of the neck of the femur. Were the anatomy such that the shaft of the femur passed directly up to the acetabulum abduction would be impossible. As it is the femoral neck becomes the radius of a circle having the femoral head for a centre while the tip of the trochanter lies on the periphery. When the limb is abducted (*Fig 289 B*) the trochanter passes upward through the arc of a circle thus approaching the anterior superior spine and the extent to which the level of the trochanter will have been raised will be made evident by the shortening recorded by the tape measure. This is the mechanism of

abduction in the normal limb, but the matter becomes altogether different when there is a fracture of the shaft of the femur. In the presence of fracture it is not necessary that the neck of the femur should play any part at all. The trochanter need not move upwards, for the requirements of the adductor magnus will be quite as well, and more easily, met by the passage upward of the lower fragment only, by over-riding of the fragments in fact, and this is what will almost inevitably occur (*Fig 289, C*)

Now, armed with knowledge of the nature and cause of the difficulty what shall we do? We take off a couple of pounds from the weight, we can also reduce the abduction by shifting the leg with its pulleys a little towards the mid-line of the bed. Still the pelvis remains very oblique. The natural suggestion is offered that a well-padded perineal band should be applied on the injured side and tied firmly to the bed-head, by this means counter-extension and pulling up of that side of the pelvis will be secured. I, on the other

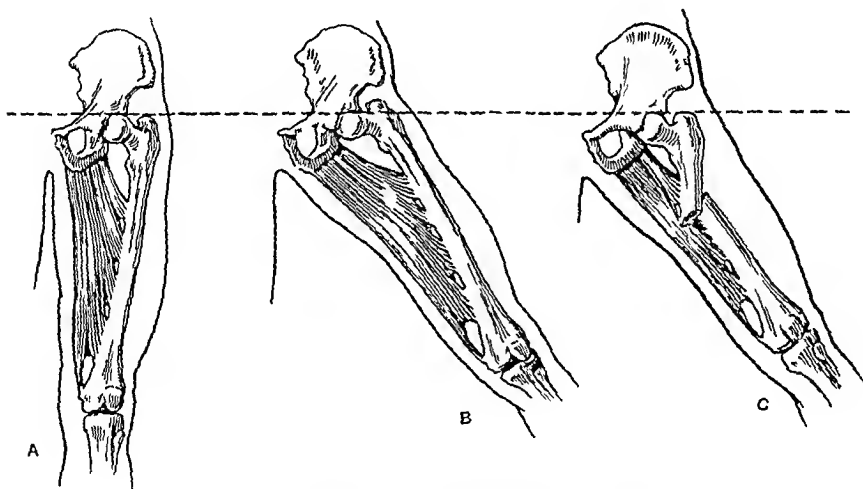


FIG 289—Illustrating the mechanism of abduction

hand, would rather put an extension on the sound side and pull that down. Finally, it is decided to wait and see, and the intelligent Sister would do what she could now and again to straighten out the little patient. The next day it was quite evident that all was going well, the length was quite right, and in short, no further measures were needed and the case gave no further trouble.

Example 4—I have left this case to the last, because it illustrates the greatest and most momentous of all the problems presented by simple fracture. The length will not come right although the case has been in two or three days. On examination there is no fault to be found with the apparatus and yet the limb remains one or two inches short. We know that the means that have been adopted are to be trusted to bring the limb to the normal length provided always that there is no mechanical impediment at the seat of fracture. When there is interposition of muscle or the fragment has been thrust through muscle, periosteum, or other fibrous tissue, and incarcerated so that the fragments cannot come into good position, the measurement will be persistently

short. Hence we are ready on the alert for now is the time to rescue the patient from one of the greatest disasters that can befall. We suspect that there is interposition of muscle between the fragments and that unless we interfere promptly the man will be pronounced in a few weeks to be suffering from an ununited fracture of the femur with three or four inches of shortening. There are two further observations we can make. First on feeling the contour of the limb we discover at some spot in the neighbourhood of the fracture a 'humpness' that is not normal due to the projection outwards of one of the fractured ends. Again take the tape measure and measure carefully the length from the anterior superior spine to the top of the patella and while the measure is held thus let the house surgeon very gradually increase the traction on the limb, the thigh is seen to lengthen out almost to normal. Now the house surgeon slowly releases the weight again, and the limb recoils like a piece of stretched rubber. This peculiar elastic recoil is quite characteristic. There is no doubt as to the diagnosis nor is there any as to the correct treatment which will be operative. The seat of fracture will be freely exposed and the surgeon must be prepared for difficulties mostly difficulties of 'seeing'. A tamponade will be helpful and usually quite worth while. The interposed tissues should be cut across rather than pushed aside and the surgeon being satisfied that the fragments have been released will close the wound and the case will thenceforth be treated as a simple fracture.

Results—It has become very clear to us that the general behaviour of fractures treated in this way contrasts favourably with that usually seen where other more 'restrictive' methods are employed. I can only explain it by suggesting that all the tissues of the limb notably the muscles and bones, preserve their nutrition better when merely laid upon a pillow with considerable freedom of movement than when subjected to the compression associated with splints and bandages. I think that union takes place more rapidly than of old and the patient is certainly up on crutches earlier and the crutches are discarded sooner. Among other things I have been struck with the remarkable rapidity with which consolidation takes place, so that the fracture will pass from almost no union to firm union in the course of a week.

A frequent experience is as follows. At the end of the third week there will be only just perceptible evidence that the fragments are beginning to join but free mobility is of course still present, a week later consolidation will be complete, so that all the apparatus can be removed. Needless to say, the capacity for rapid repair of fractures varies somewhat, but it is rare for complete consolidation to be delayed beyond the fifth or sixth week. In children firm union is constantly present before the end of the fourth week, but I make it a rule to wait until the fourth week is completed before releasing the limb. Our plan is, after the apparatus has been removed, to keep the patient in bed for a week, during this time he moves about freely in bed, and may occasionally sit on the side of his bed and dangle his legs. If union should be imperfect, there will be a loosening and an access of tenderness at the seat of fracture, but I have rarely known this to occur in a fracture treated in this way. At the expiration of the week of probation he is allowed up on crutches, and is encouraged to put a little weight on the limb,

very soon the crutches are discarded for a couple of sticks. No plaster bandage or other support is applied, nor is massage employed. I am strongly of opinion that the application of a plaster support to the limb when the patient is first allowed to walk is a source of weakening, and is favourable to bending—an observation that was made years ago, I think very acutely, by one of my colleagues at the Children's Hospital.

Newly-born and very young infants are treated in this way at the Children's Hospital. When two years ago I first saw a tiny infant lying in a cot rigged up with Lilliputian pulleys and string, and was amused thereat, the sister was so emphatic and serious in her approval that all doubt was at once banished, and no other method has since been even thought of. The nurses find that such patients give no trouble, and are tended and washed with the utmost ease and comfort.

Again I would insist that there is only one kind of faulty alignment or angulation likely to threaten trouble in fractures treated in this way, and that is the gravitational backward sagging at the seat of fracture, which is due to the lack of the most ordinary care. Outward curvature is practically never seen.

One more word as to the significance of comfort. Comfort is the first essential in the treatment of a fracture. No apparatus that is not perfectly comfortable can be a good apparatus, for the muscles will never be at rest, but will always be striving to achieve a position of greater comfort. Moreover, there is, I am convinced, a direct relationship between comfort and rapid union, and an equally direct relationship between discomfort and delayed union, feeble union, and non-union. Explain this how we may, I have no doubt whatever about the clinical fact as a matter of bedside observation. Therefore let us never be content with any means no matter how ingenious, and complicated, and satisfying to our theoretical preconceptions, that is not perfectly comfortable.

**THE RELATIVE FREQUENCY OF THE VARIOUS POSITIONS
OF THE VERMIFORM APPENDIX.
AS ASCERTAINED BY AN ANALYSIS OF 3000 CASES WITH AN
ACCOUNT OF ITS DEVELOPMENT**

By REGINALD J. GLADSTONE and CECIL P. G. WAKILLIA, London

A GREAT deal has been written concerning the position of the cæcum and appendix but notwithstanding the excellent work which has already been done, there is a general feeling that the individual experience of many surgeons and anatomists does not conform with the statements that have been published and accented with regard to the relative frequency of the different positions assumed by these organs. It was on this account that in 1914 we commenced making careful observations upon the position of the appendix as seen in the operating theatre post-mortem and dissecting rooms and by the middle of this year the total number of cases in which the position of the appendix had been recorded amounted to 3000. The cases will naturally include in addition to those in which the normal position was unaffected by inflammatory adhesions or traction bands the usual cases which are likely to be met with in surgical practice—for example the acute and chronic cases of appendicitis. We have however thought it unnecessary to complicate the classification by introducing accidental factors into the statistics. The position of an abscess is most likely to be determined by the original position of the appendix and the surrounding folds of peritoneum, and the influence of inflammation in altering the normal position of the appendix is not of sufficient importance to interfere with the general value of the statistics which we have collected. One of the objects we have had in view has been to afford an explanation of the various typical positions in which the cæcum and appendix are found, and we have thus examined a series of human embryos and fetuses up to the time of birth and included a description of the changes which they undergo during this period.

As the position of an inflamed or gangrenous appendix and its relationship to adjoining parts frequently determine the site of an abscess, it is important that the surgeon should have some knowledge of the relative frequency of the various situations in which the appendix may be found and its relationship to the surrounding pouches and folds of peritoneum.

A good deal of misconception arises out of the use of certain terms in regard to the folds of peritoneum and fossæ around the cæcum and appendix. As it is of the greatest importance that these names should denote a definite condition, we have thought it necessary at the outset to define clearly what we understand by the terms employed in this article. The terms which we propose to use are given in the following table, and details with regard to the exact position of the appendix and the peritoneal folds and fossæ follow

TABLE SHOWING POSITIONS OF THE APPENDIX, WITH THEIR
RELATIVE FREQUENCY

POSITIONS OF THE APPENDIX	NO. OF CASES	PER CENT
1 Anterior or pre ileal	27	0.9
2 'Splenic' or post ileal	15	0.5
3 'Pelvic', on psoas muscle, near or hanging over the brim of the pelvis	825	27.5
4 Sub-cæcal beneath the 'caput cæci'	56	1.86
5 Post-cæcal and retrocæcæ	2076	69.2
6 Ectopic	1	0.033
	3000	100.0

1 The Anterior or Pre-ileal Position (*Fig. 290*) is uncommon (0.9 per cent). The appendix is directed upwards and forwards towards the abdominal wall, and also medially in front of the terminal part of the ileum. The meso-appendix is unusually long, its free edge is directed upward and the appendicular border is to the right. The original posterior surface is thus turned forward and the anterior backward, so as to cover over the ileocæcal fossa, which may become obliterated as is shown in the drawing.

Should the organ become inflamed it may form adhesions to adjacent coils of small intestine, and an abscess may form between these coils and the appendix. Generally, however, the great omentum is early on the scene, and often completely surrounds the appendix, in this case the inflamed mass may be felt on abdominal palpation.

In the case represented in *Fig. 290* two lobulated folds of peritoneum containing fat extended upward one on each side of the appendix from root to tip. There was a well-marked genitomesenteric fold extending from the ileum where it was attached to the left side of the meso-appendix, down to the margins of the aperture of a hernial sac. The sac was empty about one inch in length, and its opening lay to the inner side of the origin of the deep epigastric artery, which vessel crossed above the neck from the outer to the inner side and thus closely encircled the orifice of the sac in about two thirds of its circumference. The hernial sac, although 'internal', was oblique in position and it did not appear ever to have contained any viscera. A lobulated mass of fat which occupied the lower part of the inguinal canal was adherent to its external surface and must have exerted traction on the peritoneum, drawing it downward into the canal. The 'caput cæci' descended to within one inch of the hernial orifice, and the outer and lower border of the cæcum was bound down to the outer end of Poupart's ligament and the iliac crest by four or five short parietocæcal folds of peritoneum. The posterior surface of the cæcum was directly adherent to the floor of the iliac fossa. The terminal part of the ileum was directed downward at its junction with the cæcum so as to form an acute angle with the ascending colon. At the point of attachment of the genitomesenteric fold there was a sharp bend with the convexity directed upward, and the ileum proximal to this was considerably dilated, and contained solid faecal matter. The specimen therefore,

forms a marked contrast to the case represented in *Fig 292* in which the ileum was kinked in a downward direction and the tip of the appendix was also directed downward. In both cases the ileum was held above and below by strong peritoneal bands, in *Fig 291* it appears that the upper band had obtained the mastery over the lower band, while in *Fig 292* it would appear that the lower of the two containing forces was the stronger. Both cases were found in old dissecting-room subjects and the constriction of the ileum appeared to have been of long standing.

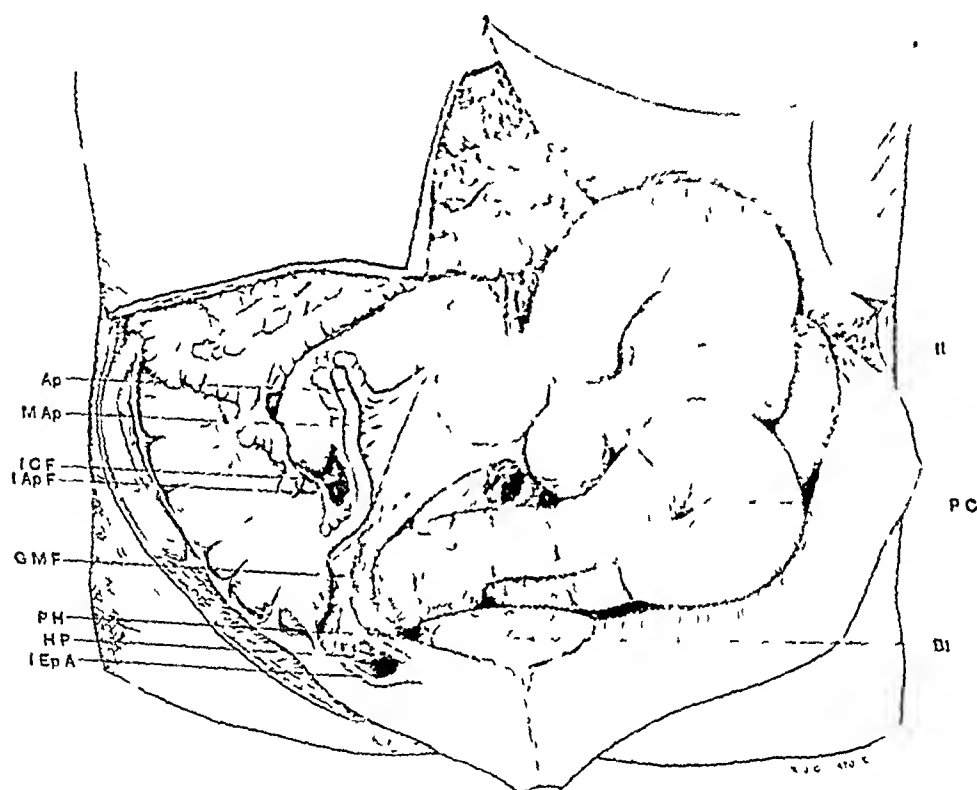


FIG 290—Pre ileal position of appendix. Observed in an aged male subject, in whom there was a well developed germotomesenteric fold connected below with the orifice of a hernial sac and the right plica hypogastrica. Above it was attached to the root of the appendix and its mesentery, and also to the terminal part of the ileum, which was kinked in an upward direction opposite the attachment of the fold. The part of the ileum proximal to the kink was distended with gas and hardened faeces.

Ap, Appendix caeci; BI, Bladder; GMF, Germotomesenteric fold; HP, Orifice of hernial sac; I Ap F, Ileocecal fold; ICF, Ileocecal fossa; I Ep A, Fold raised by inferior epigastric artery; II, Distended ileum; M Ap, Meso appendix; PC, Pelvic colon; PH, Plica hypogastrica.

2 The 'Splenic' or Post-ileal Position is still more uncommon, only 15 (0.5 per cent) were observed in our 3000 cases. The appendix passes upward and to the left beneath the mesentery, or it may be coiled up in the ileocaecal fossa (*Fig 291*) under cover of the terminal part of the ileum and the ileocaecal or 'bloodless' fold of Treves. In the specimen figured this fold was loaded with fat, and, like the ileum, it has been drawn upward in order

completely to expose the appendix. The appendix and its mesentery were adherent to a well-marked genitomesenteric fold, to the right of which was a parietocæcal band which passed upwards behind the 'caput cæci' to the root of the appendix. A narrow and deep recess lay between the genitomesenteric and parietocæcal folds, which we regard as a subdivision of the post-cæcal fossa. In the 'splenic' type of the post-ileal position of the appendix, where the tip is directed upwards and to the left beneath the mesentery, there is a likelihood, should inflammation occur, of the appendix becoming adherent to the mesentery, and setting up mesenteric thrombosis. Should the appendix be retroperitoneal it may lie behind or even within the root of

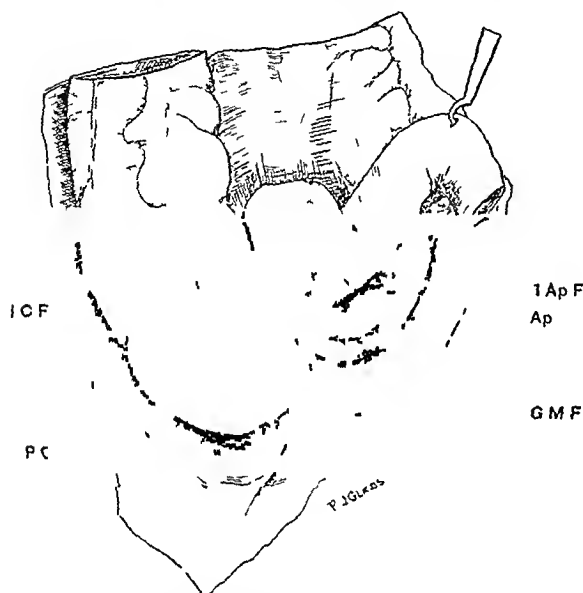


FIG 291.—Post ileal position of appendix. From an old dissecting room subject, showing the tip of the appendix lying in the ileocecal fossa. The ileo appendicular fold is loaded with fat, and with the terminal part of the ileum has been drawn upward, so as to expose the appendix. A subcecal fossa is divided by a parietocæcal fold into an outer part lodging the cecum, and an inner which is bounded medially by a genitomesenteric fold.

Ap, Appendix. GMF, Genitomesenteric fold. IApF, Ileocecal fold. ICF, Ileocecal fossa. PCF, Parietocæcal fold.

the mesentery (intramesenteric position). In such cases, if inflammation occurs, mesenteric thrombosis is almost inevitable.

3 The 'Pelvic' or Descending Position is quite common, 27.5 per cent in our series. In this type the appendix passes downwards on the psoas muscle and may overhang the hump of the pelvis. The meso-appendix is usually long, and there is often a genitomesenteric fold, lying medial to the appendix and its mesentery. This is usually attached to the ileum on the under surface of the mesentery of the small intestine about three inches from the ileocecal valve (Fig 292). In this specimen there was a marked constriction of the ileum and a kink in the downward direction so that the terminal part of the ileum ascended to the ileocecal valve. The mesenteric attachment of the meso-appendix had in consequence been drawn downwards with the terminal

part of the ileum and the descending position of the appendix had thus been rendered possible. In Fig 290, showing the ascending or pre-ileal type, the reverse condition is present, the meso-appendix is drawn upward with the ileum, which in this case descends from an upwardly-directed kink to the ileocecal valve. In the example shown in Fig 292 of the descending type it will be seen that there is great distension of the ileum on the proximal side of the constriction, and also that the testes are incompletely descended. The penis and scrotum are small, and the pubic hair scanty. The lower end of the genitomesenteric fold is subdivided into an ill-defined ridge

continuous with the fold raised by the obliterated hypogastric artery and a fold running towards the internal abdominal ring

If inflammation should occur in an appendix overhanging the pelvic brim in the female, it may become adherent to the right ovary, and pain may occur in the right iliac fossa during menstruation. An inflamed appendix sometimes becomes adherent to the bladder or rectum and in such cases painful micturition or defecation may occur and should an appendicular abscess form it may discharge into the bladder or rectum.

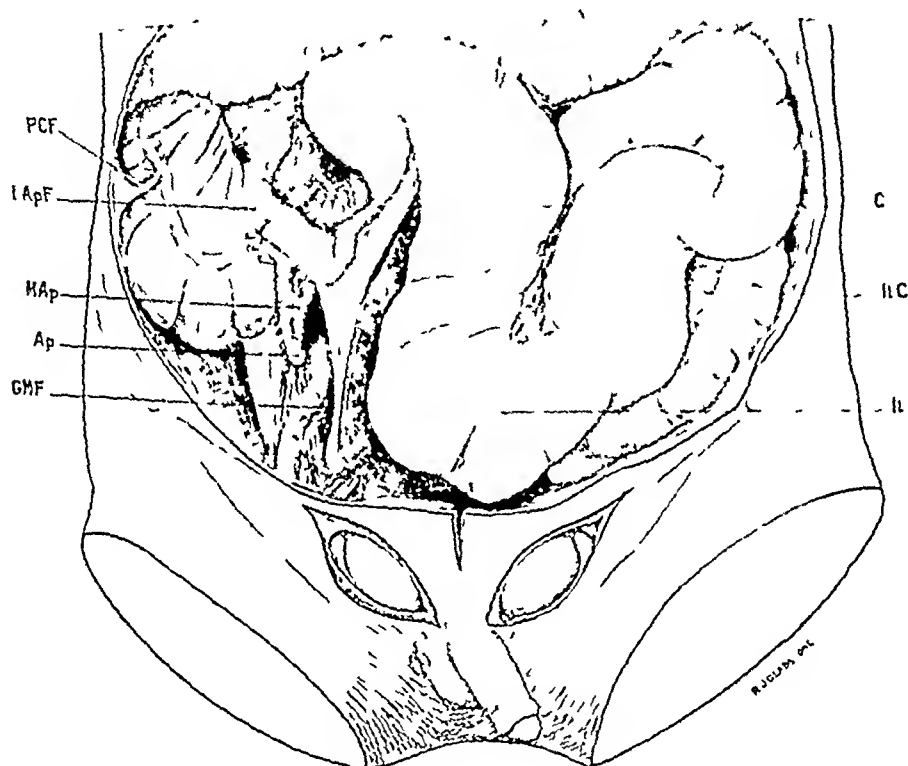


FIG. 292.—Descending position of appendix. The appendix is directed downwards, and lies on the right psoas muscle. Its tip overhangs the brim of the pelvis and is in relation with a tortuous external iliac artery. A well-developed genitomesenteric fold is present, which has caused a downward kink and constriction of the ileum. The portion of ileum proximal to the constriction was tensely distended with flatus. The testicles were incompletely descended, and the external genitalia small.

Ap, Appendix. C, Constriction of ileum. GMF, Genitomesenteric fold. IApF, Ileoappendicular fold. II, Distended portion of ileum. IIC, Iliocolon. MAp, Mesoappendix. PCF, Parietocolic fold.

1. The 'Sub-cæcal' Position of the appendix beneath the 'caput cæci' (Fig. 293) is not so uncommon as one might be inclined to think—18.6 per cent in our cases. The appendix lies in the lower part of the iliac fossa, and is usually turned to the right. It is often coiled or kinked. The ileo-appendicular fold is usually small or absent. In the specimen drawn a sharply-defined fold of peritoneum passed from the posterior surface of the ileum to the lower part of the iliac fossa, where it terminated above and to

the outer side of the external abdominal ring. It limited the sub-cæcal fossa below and internally, and probably represented a genitomesenteric fold, the upper end of which had descended with the ileum, so that the direction of the band had been changed from the vertical to the horizontal. The terminal part of the ileum in these cases is frequently found ascending from the pelvis to the ilio-cæcal junction, and having a direction which is in line with the ascending colon. If inflammation occurs in the appendix in this position, an abscess may form, which sometimes bursts through the fascia iliaca into the iliacus muscle, and gives rise to flexion of the hip-joint owing to spasm of the muscle. A variety of post-cæcal fossa containing the appendix has been described beneath the iliac fascia. This we consider to be produced as a secondary result of inflammation.

5 The 'Post-cæcal' and Retrocolic Positions—The group including these positions is the most common in our series, there being 2076, or 69.2 per cent. This is in accord with the general experience of both surgeons and anatomists

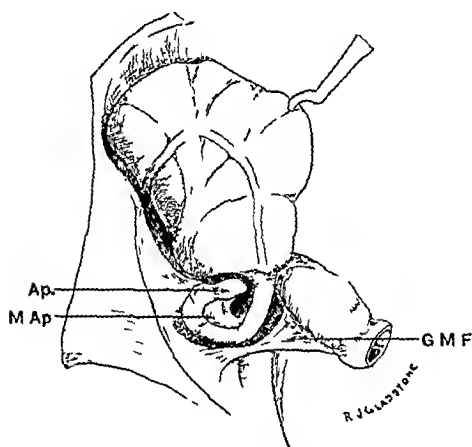


FIG. 293.—Sub-cæcal position of appendix. The appendix lies under cover of the 'caput cæci' in a post-cæcal fossa, which is limited below by a horizontally placed genitomesenteric fold.

Ap, Appendix. G M F, Genitomesenteric fold. M Ap, Mesentery of appendix.

at the present time, but differs markedly from the statistics which have been published by previous writers and quoted in many of the standard text-books. This may be accounted for partly by the difficulties which arise from one group overlapping another, and partly from the subdivision of the posterior positions, which are essentially the same, into two or more groups, thus masking the true frequency of this *most common type*.

The appendix may be found—

a Free in a post-cæcal or retrocolic pouch of peritoneum.

b Held in contact with the cæcum or the ascending colon by a short mesentery.

c Adherent to the cæcum or colon, which, with the appendix, form the anterior wall of a retrocolic pouch of peritoneum.

d Behind the cæcum and ascending colon, but, owing to obliteration of the retrocolic pouch, entirely extraperitoneal.

There is no doubt that inflammatory changes occurring in the appendix may cause a perfectly free appendix in position (a) to become adherent to the cæcum and so come into sub-division (c). There is also, however, a considerable amount of variation in the degree to which the cæcum and ascending colon become adherent to the posterior abdominal wall and iliac fossa in the course of normal development, apart from any secondary adhesion caused by inflammation.

As an accurate knowledge of the position of the appendix, and of the various foldings of the adjacent parts of the peritoneum during fetal life are essential for the explanation of the fixation of the cæcum and appendix in the normal positions in which they occur in the adult, and more especially of some

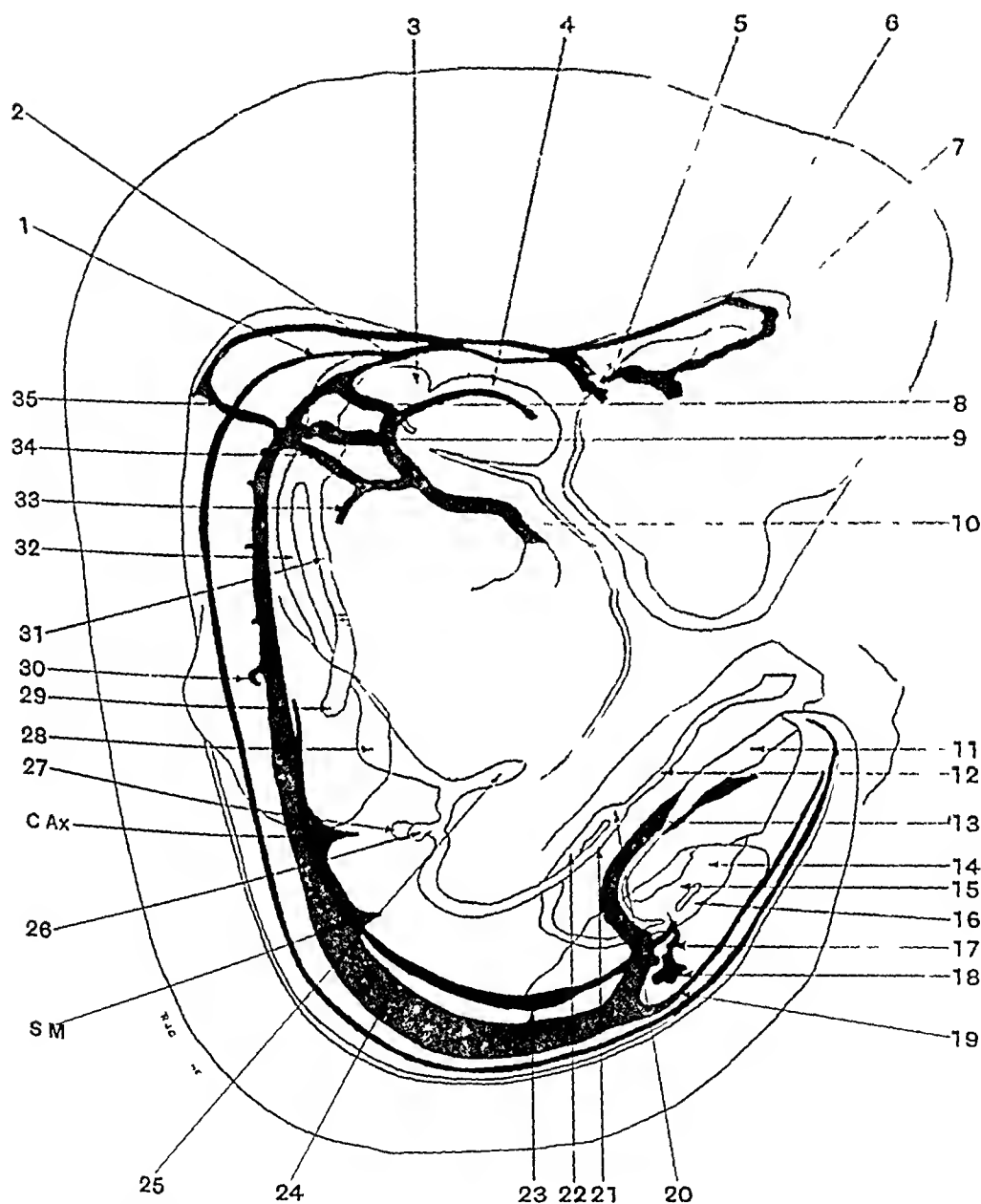


FIG 294.—A linear reconstruction from serial sections of a human embryo 9 mm in length, aged about 4½ weeks. The embryo is seen at a magnification of 15 diameters. There were 407 sections, 10 μ in thickness. Every second section was drawn, and the parts shown in the drawing were plotted on 'millimetric paper'. The figure shows the cephalic or proximal limb of the umbilical loop of the intestine lying to the right of the caudal or distal limb which it crosses near the thickening which marks the position of the future cecocolic appendix and ileocecal junction. The vitello intestinal duct or stalk of the yolk sac is attached to the summit of the umbilical loop.

1 Notochord 2, Internal carotid artery 3 Tongue 4 Mandibular arch 5 Ophthalmic artery 6 Anterior cerebral artery 7 Posterior cerebral artery 8, Third arch 9, Fourth arch 10 Aorto pulmonary trunk 11, Allantois 12, Vitelline duct 13 Umbilical artery 14 Cloaca 15 Urethrovaginal tube 16, Rectum 17, Ureter 18 Renal bud 19, Middle sacral artery 20 Umbilical loop 21 Cephalic limb 22, Caudal limb 23 Mesonephric duct 24 Abdominal aorta 25 Gall bladder 26, Left or dorsal pouch 27 Right or ventral pouch 28, Stomach 29, Right lung 30, Subclavian artery 31 Trachea 32, Esophagus 33 Pulmonary artery 34 Sixth arch 35 Primitive vertebral artery C Ax Coeliac axis S M Superior mesenteric artery

of the more unusual sites of the appendix such as the intramesenteric or extraperitoneal, we have considered it necessary to describe in some details the various phases of its development from its first appearance until birth. The unusual positions referred to may not only give rise to difficulty in finding the organ, but may predispose to obstruction, kinking, and inflammation, and a knowledge of the developmental aberration or defect which has produced a particular condition will prove of the greatest value in dealing with the condition quickly and effectively.

The early stages of development have been admirably described by Kelly and Hurdon in their work on *The Appendix Vermiformis and its Diseases* 1905. This description is based on an investigation of 54 human embryos from the private collections of the late Franklin P. Mall and M. Max Brodel. We shall therefore merely allude to certain points of general interest which have been observed by us during its extra-embryonic stage, and shall describe more fully the later phases of its development, from the return of the intestine from the 'umbilical coelom' into the abdominal cavity until birth.

The first indication of the ileocaecal junction occurs in embryos from 5 to 5½ weeks old and from 5 to 7.5 mm in length. The intestine then projects forwards into the root of the umbilical cord, in the form of a wide V-shaped loop. The proximal part of this loop is continuous with the duodenal end of the foregut, and is termed the cephalic limb, the apex projects forward within the umbilical extension of the peritoneal cavity or umbilical coelom into the root of the cord, and is continuous with the stalk of the yolk-sac, the distal part of the loop is continued into the hind gut, and is termed the caudal limb. The loop is connected with the posterior wall of the abdomen by a dorsal mesentery which is attached to this wall along an approximately medial line. It contains the omphalo-mesenteric or vitelline vessels, which will afterwards be represented by the single superior mesenteric artery and vein. Near the distal end of the caudal limb of the loop a slight bulging is present, which is the first indication of the caecum and appendix, and of the junction of the small with the large intestine.

FIG. 295.—Two stages illustrating the life history of the 'transient appendix', after Max Brodel and Mall, from *The Appendix Vermiformis and its Diseases* (Kelly and Hurdon). A represents an early phase in its development during the 6th week, B an atrophic stage preceding its degeneration and disappearance from a 7 weeks embryo.



In an embryo of 9-mm length which has been reconstructed from serial sections by one of us (R. J. G.) after the linear projection method (Fig. 294), the loop of intestine is seen to project considerably farther forward into the umbilical cord, and has become twisted so that the caudal limb lies to the left and nearer the head end of the embryo, while the cephalic limb is to the right and nearer the tail. The stalk of the yolk sac is now reduced to a narrow tube, the vitello-intestinal duct which is attached to the summit of the loop, and at this stage helps to hold it in position.

Between the 6th and 7th weeks, in embryos of from 10-mm to 20 mm length, a considerable elongation of the caecal bulging takes place and its

longitudinal axis at first slight, and in line with the longitudinal axis of the colon usually becomes bent so as to form a U-shaped figure with the commencement of the colon. This is apparently the result of traction excited on the cæco-appendix by its mesentery, which is drawn out from the common mesentery as the cæcum elongates. A remarkable outgrowth from the tip of the cæcum is also present at this stage of development (Figs 295 and 296), which simulates in its position and form the true vermiform appendix but since it atrophies in embryos of 20-mm length and afterwards completely disappears it is believed to be an independent structure, and not connected with the permanent appendix cæci, which is differentiated later. Possibly it represents one of the two cæcal diverticula which are found in buds, and appears only as a vestigial and transitory structure in the human embryo whereas the other develops later and persists as the permanent 'appendix cæci'.

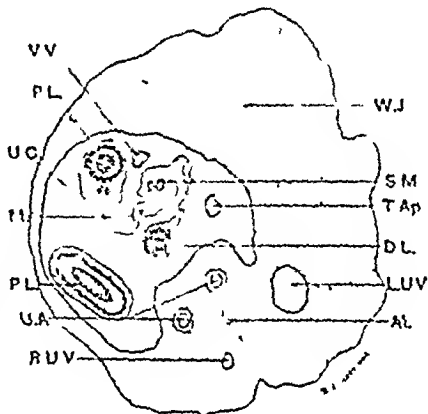


FIG. 296.—Transverse section through the umbilical cord of a human embryo 20 mm in length obtained from a laparotomy performed by Mr Sidney Boyd. The transient appendix, *T Ap*, is seen to the left (right side in the drawing the section being seen from in front) of the umbilical loop of intestine and its dorsal mesentery. No lumen is present, except at its root, where it springs from the cæco-appendix. The appendix is directed forward away from the embryo and the portion of the distal limb of the loop, *DL*, below and to the right of it is the terminal part of the ileum (Compare Fig. 298).

II, Allantois *DL*, Distal limb of umbilical loop, cut near the termination of the ileum *LUV*, Left umbilical vein, already greatly exceeding the right umbilical vein, *RU*, in size *M*, Mesentery of small intestine containing branches and tributaries of the superior mesenteric artery and vein, *SM*. In this position these vessels are incorporated in the mesentery, lying between its two layers farther forward in the region of the vitello intestinal duct they lie, like the vitelline vein, *V*, free in the umbilical coelom *PL*, *P L*—Proximal limb of umbilical loop *T Ap*, Transient appendix *UA*, Umbilical arteries *UC*, Cavity of umbilical coelom *WJ*, Whartonian jelly.

The mechanism of this return of the alimentary canal into the abdominal cavity, and the relative positions which are subsequently assumed by the large and small intestines, have been well described by Professor J E Frazer and Dr R H Robbins in an article entitled "Factors concerned in causing the Rotation of the Intestine in Man" *.

The typical relations of the cæco-appendix soon after the return of the

intestines into the abdomen are well seen in *Fig 297*, which is a drawing, taken from in front, of a model reconstructed by one of us (R J G) according to the wax-plate method of Boin, from serial sections of a 45-mm human

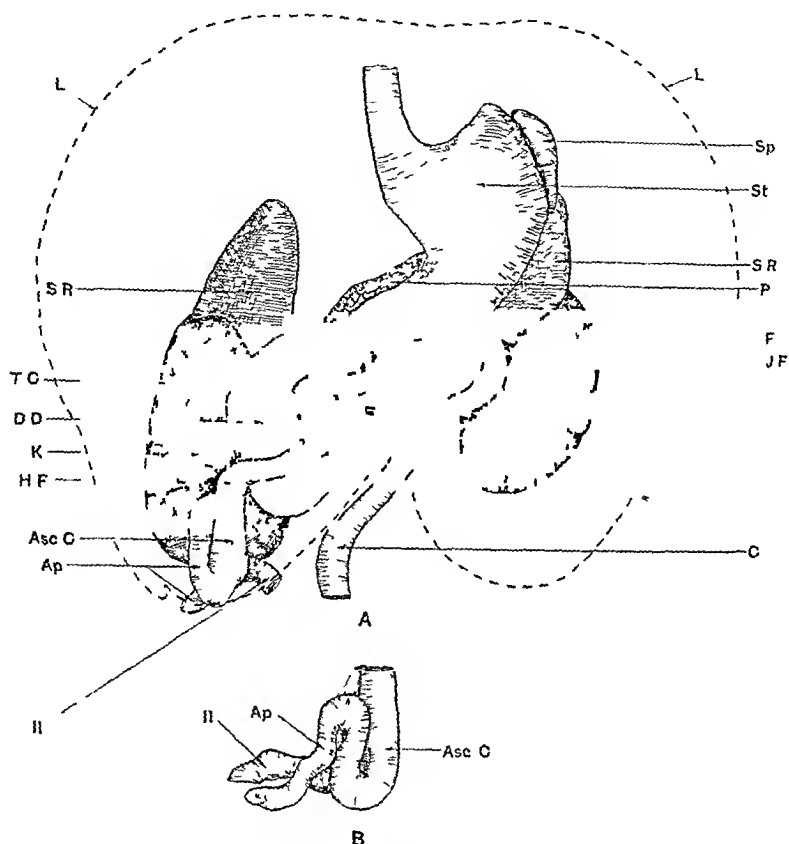


FIG 297—A Drawing of a model, reconstructed from serial sections of a 45 mm human embryo, showing the relative positions of the viscera in the upper part of the abdominal cavity. The outline of the liver, *L*, is represented by an interrupted line. It will be noted that the ascending colon which is very short lies entirely under cover of the liver, and in front of the lower part of the right kidney a wide angle marks the position of the hepatic flexure of the colon, which lies between the cæco-appendix and duodenum. Thence the transverse colon passes obliquely upwards and to the left across the descending duodenum, head of pancreas, and commencement of the jejunum, to the left suprarenal body. Here it forms a loop behind the pyloric part of the stomach (splenic flexure). This loop lies a considerable distance below the level of the spleen, which has not yet grown down to its permanent position relative to the left suprarenal body and kidney. The descending colon then passes obliquely downwards and to the right below the obliquely placed third portion of the duodenum. The ileocecal junction lies just below the lower end of the right kidney and is separated from the posterior abdominal wall by coils of ileum. The liver lies to the right and in front coils of intestine lie in front of as well as behind the cæcum and appendix. (See *Fig 299*, which is a drawing of a section from the series used in the construction of the model taken just below the inferior pole of the right kidney.)

B represents the cæcum and appendix, viewed from the right and shows the Ω -shaped bend the terminal part of the ileum and ascending colon

embryo. The position of the liver is indicated by an interrupted line. It will be seen that the cæco-appendix has moved to the right of the median plane and lies under cover of the right lobe of the liver. It is coiled in the form of a Ω -shaped bend. The proximal limb of the loop runs upward from

the ileocaecal junction behind the colon it then turns backwards forming the summit of the Ω -shaped bend and finally downward as the descending limb which terminates in a free extremity the tip of the appendix which appears just below the inferior border of the liver. It is situated just below the ileocaecal junction and above the highest point of the iliac crest at the level of the body of the 11th lumbar vertebra. The differentiation of the caecum from the appendix has not yet taken place. It is probable,

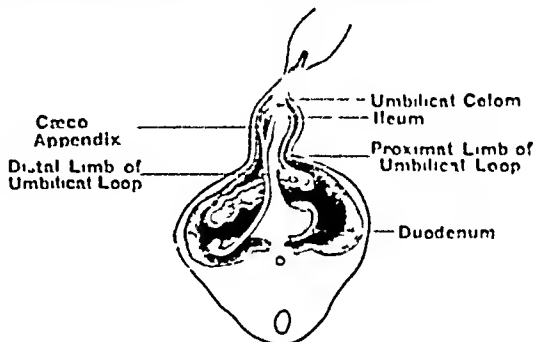


FIG. 298—Drawing representing the lower half of the trunk and a portion of the umbilical cord seen from above. Slightly modified from Irazar and Robbins. The figure shows diagrammatically the relation of the terminal part of the ileum to the caeco-appendix and the commencement of the colon. The caeco-appendix lies above the coils of the small intestine, and these authors believe that it is the last part of the loop to return into the abdominal cavity. This diagram should be compared with Fig. 296, which depicts a transverse section of the umbilical cord just beyond the tip of the caeco-appendix.

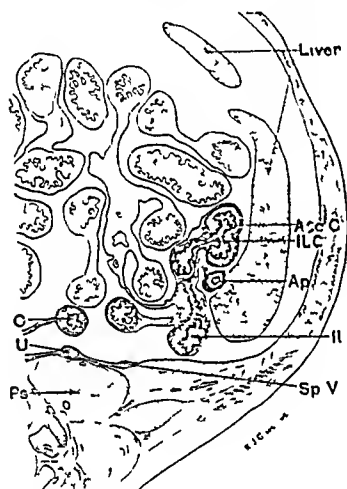


FIG. 299—A camera lucida drawing through the ileocaecal junction, from one of the sections of the 4.5 cm embryo from which the model, Fig. 297, was reconstructed. The descending limb of the Ω -shaped caeco-appendix lies between the terminal part of the ileum and the right lobe of the liver, and coils of intestine intervene between the caeco-appendix and the posterior abdominal wall. The descending colon and its mesentery (the future pelvic colon) are seen in front of the psoas muscle and ureter, and to the right of the latter are the spermatic vessels lying in the plica vascularis.

Ap, Appendix Asc C, Ascending colon C, Descending colon II, Ileum Ile C, Ileocaecal orifice Ps, Psoas major Sp V, Spermatic vessels U, Ureter

however, that the future caecum is represented by a slight bulge of the large intestine immediately below the ileocaecal junction, and that the whole of the Ω -shaped bend will give rise to the appendix. The ileum passes forward medial to the caeco-appendix, and enters the colon from below and to the left (Fig. 299). Thus, the rotation of the ileocaecal junction from its primary position, which is on the right of the colon (Fig. 298), to its permanent position behind and to the left, has already taken place. This rotation is due to the movement of the caeco-appendix from the median place in which it lies at the time of its entrance into the abdomen, in a direction downward and to the right, beneath the liver, combined with a movement of the terminal part of the ileum with its mesentery in the reverse direction from right to left. At this stage the lower part of the right lobe of the liver is lateral to the caeco-appendix (see Fig. 299) and the commencement of the colon, and coils of small intestine lie behind, and thus separate them from the posterior abdominal wall and right kidney (Fig. 299), moreover, the attachment of the common mesentery of the small intestine and colon is still approximately mesial. In

the duodenal region, however, the root of the mesentery is curved towards the right, and is continuous with the mesocolon, where the mesenteric pedicle turns anti-clockwise round the axis of the superior mesenteric artery, the mesocolon thus crosses the head of the pancreas and the descending part of the duodenum, as in the adult, though the omental bursa has not yet become adherent to the transverse colon and its mesentery. Since coils of intestine intervene between the cæco-appendix and the posterior abdominal wall, and there is a long mesocolon, the cæcum is free to move in a downward direction into the iliac fossa. In the 45-mm embryo from which the model has been

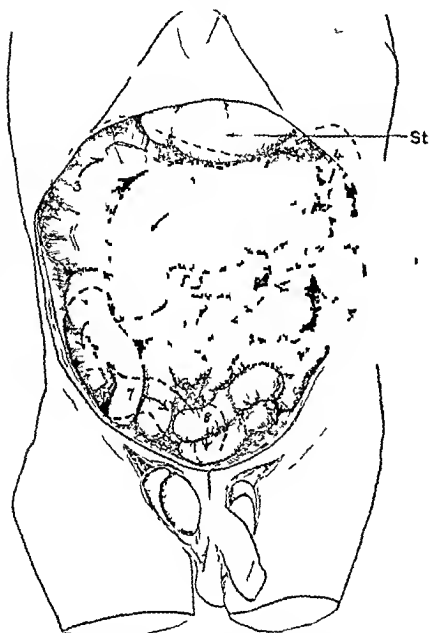


FIG 300—Ectopic position of the cæcum and appendix, from a dissecting room subject in which the testes were imperfectly descended. The cæcum and appendix were free and displaced upwards and to the left beneath the stomach in front of and below the transverse colon which is represented by the dotted lines between 3 and 4; the hepatic flexure lies between 2 and 3; the splenic flexure at 4. The loop formed by the 'pelvic colon' remains in the foetal position, namely in the lower part of the abdomen and right iliac fossa; its course is represented by the dotted lines and arrows 5, 6, 7; it lay for the most part behind the small intestine, except for a small portion indicated by the arrow between 6 and 7, where it occupied the right iliac fossa.

rotation of the terminal part of the ileum with its mesentery beneath the cæcum and the proximal part of the colon, which are carried to the right, an angle is formed between the mesocolon carrying the right and middle colic arteries and the terminal part of the mesentery of the small intestine enclosing the vasa intestini tenuis. At the apex of this >-shaped bend is the

reconstructed, it already lies just above the level of the iliac crest, although it is almost completely under cover of the right lobe of the liver. The position of the cæco-appendix at this stage appears to vary considerably in different specimens. This is largely due to the degree of rotation that has taken place at the ileocolic junction, thus, in a 45 mm embryo figured by Frazer and Robbins the ileum enters from the right side and the appendix is directed upwards in front of it; in another specimen representing a later stage the ileum enters the colon from below, and the appendix is directed horizontally to the right; in our own specimen the rotation is complete, the ileum enters from behind and from the left (Fig 297) and the appendix is retrocolic in position (Fig 299).

Should coils of small intestine remain between the right lobe of the liver and the cæco-appendix, this, with the proximal part of the colon, may be pushed to the left (Fig 300) and take up a position beneath the stomach and transverse colon, with the tip of the appendix directed to the right and lying below the proximal part of the colon which courses horizontally from left to right, instead of ascending in the right lumbar region to the liver.

At this stage, immediately after the

ileocolic artery which sends an anterior cecal branch in front of the ileocolic junction, and a posterior branch behind the ileum to the posterior surface of the cæco-appendix. This branch runs in the mesentery of the cæco-appendix and persists as the appendicular artery which in the adult runs near the free border of the meso-appendix. Should the appendix become caught in the receding angle between the two lamellæ of the >-shaped fold, it will be held in an intramesenteric position at the root of the mesentery, ('intramesenteric position*') or it may lie in the anterior wall of a retrocolic or retro-ileal pouch, and should the pouch become obliterated by adhesion and absorption of its walls the appendix will be completely extraperitoneal. In the latter case it may be readily exposed by dividing the peritoneum below the cæcum and carefully raising the 'caput cæci' from the iliac fossa.

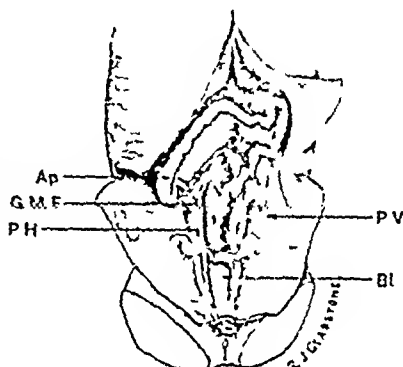


FIG. 101.—Drawing of a dissection showing the cecum and appendix lying at the level of the right iliac crest and the position of the colon and its mesentery in a fetus at the end of the third month. The small intestine has been removed so as to show the root of the mesentery and the mesocolon. The appendix was directed upwards behind the ileocolic junction and ascending colon. A genitomesenteric fold passed from the posterior aspect of the broad ligament and the brim of the true pelvis upwards over the 'plica hypogastrica' and right psoas major to the posterior aspect of the mesentery of the small intestine. It had a free border directed to the right, and a wide basal attachment corresponding internally to the line of the ovarian vessels. Its lower part and root of attachment therefore correspond to the 'plica vascularis'. A similar fold is present on the left side, which in the later stages of development would be covered and obliterated in the greater part of its extent by the growth over it of the pelvic mesocolon.

Ap, Appendix. Bl, Bladder turned downwards with the anterior wall of the abdomen. G M F, Genitomesenteric fold. PH, Plica hypogastrica. PV, Plica vascularis (¼ in beyond arrow).

Connected with the lower surface of the mesenteric laminae of the >-shaped bend is an important fold of the peritoneum which runs vertically downwards to the brim of the true pelvis and vicinity of the future internal abdominal ring (Figs 290-293 and 301). This fold has been described by various authors under different names of which perhaps the best is the 'genitomesenteric'. Its connections have been described by R. Douglas Reid in several articles recently published in the *Journal of Anatomy and Physiology*, and he believes it to be instrumental in causing the descent of the mesentery of the small intestine, with a consequent lowering of the mesenteric root; he also states that it is the commonest cause of a retrocolic position of the appendix. The fold is usually triangular, having an anterior surface directed forward and to the left, a posterior surface directed backwards and to the right. Of the three borders, two are fixed and one is free. Thus, there is usually a posterior fixed border attached to the posterior abdominal wall and extending from the duodenal region downwards on the right psoas muscle to the pelvis, an upper attached border connected with the under surface of the mesentery of the small intestine near the ileocolic orifice, or with the ileum in the same situation, and a free border

* An interesting example of the intramesenteric position of the appendix has been recorded by Nicola Novaro, in the *Gaz. d. Osp.*, 1921, *An.*, 147.

usually directed forward and to the right. The lower end of the fold in the female passes over the bump of the pelvis, on to the posterior aspect of the broad ligament of the uterus, and is frequently blended with the suspensory ligament of the ovary. In the male, it may end in the neighbourhood of the internal abdominal ring, or pass over the bump of the pelvis to the lower end of the fold raised by the obliterated hypogastric artery. The genitomesenteric fold may contain between its layers a thick stratum of extraperitoneal connective tissue, which in some cases forms a traction band of considerable strength, it may thus give rise to kinking and constriction of the terminal part of the ileum, or a displacement downwards and inwards of the ileum, and with it the cæcum and appendix.

Various factors appear to be concerned in the formation of this fold. Of the folds which are present in the embryo, we may consider first the

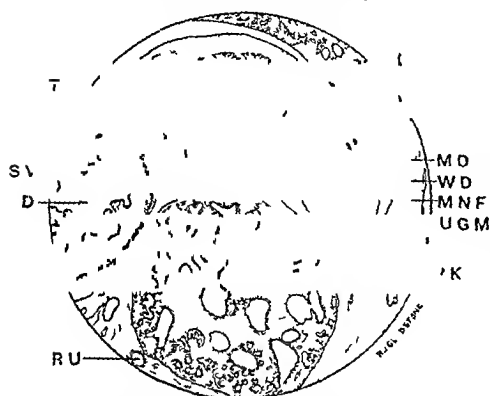


FIG 302.—Camera lucida drawing of a transverse section through a 35 mm human embryo, showing the relations of the testis and mesonephric fold to the duodenum, kidney, and liver.

D, Duodenum; L, Liver; MD, Müllerian duct; MNF, Mesonephric fold; RK, Right kidney; RU, Right ureter; T, Testis; SV, Internal spermatic vessels; UGM, Urogenital mesentery; WD, Wolfian duct.

'urogenital mesentery'. This connects the genital gland and mesonephros (Wolfian body) to the posterior abdominal wall (Fig 302). It is continuous at its upper end with the 'plica vascularis' or diaphragmatic ligament, and in the pelvic region is connected by the inguinal fold containing the gubernaculum with the internal abdominal ring. Following the degeneration which takes place of the upper part of the mesonephros and genital gland, there is also a degeneration and apparent displacement downwards of the diaphragmatic ligament as far as the origin of the internal spermatic or ovarian vessels which descend in the fold—now known as the 'plica vascularis'—to the testicle or ovary. The lower end of the fold persists in the adult female as the ovarioepelvic ligament, or suspensory ligament of the ovary, with which the

genitomesenteric band is frequently incorporated, and in the male passes downwards on the external iliac vessels to the internal abdominal ring, with which the lower end of the fold is sometimes associated, as in a case of patent 'processus vaginalis' in an adult male described by Douglas Reid* in 1913. In this case, as in the specimens represented in Figs 290, 291 and 293, the genitomesenteric fold formed the left boundary of a retrocolic fossa. In Reid's case, the appendix, which was in contact with the right or posterior surface of the 'plica genitomesenterica', could not be withdrawn from the fossa on account of an adhesion of its mesentery to the genitomesenteric fold.

On the left side, the upper part of the 'plica vascularis' is, in the normal course of development, obliterated by the adhesion of the left side of the

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primitive mesocolon to the peritoneum covering the posterior abdominal wall. When the descending and iliac portions of the colon are carried to the left by the pressure of the enlarging coils of small intestine which fill the concavity of the Π -shaped curve of the colon the 'plica vascularis' is completely covered over by the mesocolon and disappears. A similar obliteration of the upper part of the 'plica vascularis' takes place on the right side, owing to the folding over of the mesentery of the ascending colon and terminal part of the ileum, and its adhesion to the peritoneum on the right side of the posterior abdominal wall. On the right side, however, the obliteration is not so extensive owing to the lower attachment of the mesentery of the small intestine being at a considerably higher level than that at which the iliac colon crosses the brim of the pelvis to become continuous with the pelvic colon on the left. The primary position of the plica is well seen in *Fig. 301* in which the colon is still almost medial in position. The small intestine has been cut away so as to show the relation of the upper end of the gentomesenteric fold to the posterior surface of the mesentery of the small intestine. It will be seen to cross the fold raised by the hypogastric artery, and the free border is directed to the right. The relationship of the 'plica vascularis' to the posterior abdominal wall in a 15-cm. human embryo is well seen in *Fig. 299*. It lies in front of the psoas muscle and contains the spermatic vessels between its layers. The position of the urogenital fold and internal spermatic vessels at an earlier stage (35 mm.) is shown in *Fig. 302*, in which adhesion has not yet taken place. It will be observed that the genital gland and mesonephric fold are connected to the posterior abdominal wall by a thin mesentery, which, as it is common to the genital gland and mesonephros, is termed the 'urogenital mesentery'. The testis is lying in the same horizontal plane as the permanent kidney, liver, and duodenum. Sections of the spermatic vessels are cut across in the hilum (mesogentale) of the testis, and to the right is seen the degenerating Mullerian duct, lying in the free border of the tubal part of the fold. The Wolffian duct and some of the epigenital tubules of the mesonephros are cut across in the glandular part. Felix has shown that the apparent descent of the genital glands, mesonephros and Wolffian ducts in the early stages of development is due to a degeneration of the upper (cranial) portion, which occurs simultaneously with the growth of the lower (caudal) pole. Accompanying this degeneration of the structures contained in the urogenital fold is a descent of the diaphragmatic ligament as far as the level of the lowest 9 to 11 pairs of mesonephric arteries which are present in a 19-mm. embryo, and which are represented in the adult by the internal spermatic or ovarian arteries, these are contained in the urogenital fold, and extend from their origin from the abdominal aorta, at the level where this vessel is crossed by the duodenum, to the genital gland. The fold of peritoneum in which they lie is now spoken of as the 'plica vascularis', this corresponds in its upper part, where it lies on the psoas muscle, to the line of attachment of the gentomesenteric fold, and ends below in the genital gland. It appears probable, therefore, that the gentomesenteric fold originates from that part of the urogenital fold which contains the definitive internal spermatic or ovarian arteries. The position of the spermatic vessels on the psoas muscle as seen in *Fig. 299*, and the appearance of the

border of a peritoneal fold to the outer side of these vessels give the impression that degeneration of the urogenital fold above the level of the testis has not been complete, and that the fold has become adherent to the peritoneum covering the psoas muscle. At a later stage of development the mesentery of the terminal part of the small intestine and commencement of the colon will adhere to this part of the peritoneum, which, should the view expressed above be correct, affords a ready explanation of the relation of the upper end of the genitomesenteric fold to the posterior surface of the mesentery of the ileum in this position, and its connection below with the suspensory ligament of the ovary or—in the male—the upper end of the inguinal canal.

The upper part of the genitomesenteric fold thus appears to originate from an adhesion of the ileac mesentery to the right 'plica vascularis' and remnant of the mesonephric fold, and its lower part appears to be related in the male subject to the inguinal ligament and gubernaculum testis, and in the female to the suspensory ligament of the ovary. It is probable also, as has been suggested by R. Douglas Reid, that by its traction on the ileum the band is instrumental in causing the descent of the cæcum and appendix into the right iliac fossa.

The strong bands that are sometimes present in this situation in adult and more especially aged subjects (*Figs 290 and 292*), and which may give rise to kinking and obstruction of the ileum, are obviously due to an abnormal development of fibrous and muscular tissue within the normal fold. The abnormal development or hypertrophy of the sub- or extra-peritoneal tissue may be explained, as has been demonstrated by Arbuthnot Lane, on the assumption that forces, such as peristaltic action or gaseous distension of the intestine, exert traction which is resisted by the development of a band which will act as a counteracting force in the opposite direction. Should these forces, as frequently happens, be exerted along the line of the normal fold as described above, this fold will become exaggerated and the extra-peritoneal tissue between its layers will become hypertrophied and condensed so as to form a strong 'retention band' capable of causing displacement and obstruction of the intestine.

We do not propose in this paper to describe variations in the form of the cæcum and appendix, nor to refer further to peculiarities in the position of the various folds and fossæ associated with this region. These have been ably and exhaustively described by various authors, reference to whom, along with detailed descriptions, will be found in articles by Sir Frederick Treves, Douglas Reid, and in Kelly and Hurdon's *The Vermiform Appendix and its Diseases*.

Among the rarer conditions of the cæcum and appendix which are of surgical interest, we may however refer to two important abnormalities, namely—(1) Congenital absence of the appendix, (2) Its position in the left iliac fossa in transposition of the viscera. An example of the former was described by one of us, in 1916 in the *Journal of Anatomy and Physiology*. The condition is extremely rare. No instance of it has occurred in the 3000 cases on which our classification has been based, and in another series

of 1352 systematic observations only one example, recorded by Lawcett and Blatchford occurred. Several other cases however have been published or preserved in museums. These illustrate arrest of development at different stages, namely "Absence of the cæcum and appendix" (Robinson) "Rudimentary cæcum without appendix" (Sutton and Chill) "Blunt, conical cæcum without appendix" (Huntington) "A cæcum having a rounded symmetrical form with the longitudinal muscular bands converging towards its apex but without appendix" (Huntington) "Asymmetrical form without appendix" (Gladstone).

The position of the cæcum and appendix in the left iliac fossa associated with general transposition of the viscera although rare, is of sufficient practical importance to merit a brief notice in this article. As was the case in absence of the appendix, no instance of this abnormality has occurred in our 3000 observations. One of us however, when a student attending the Pathological Department of the General Hospital, Vienna met with an example of general transposition of the viscera in a female child age 18 months, who died from pyæmia secondary to scarlet fever, and through the kindness of the acting Professor of Pathology, Herr D'Albicht was enabled to obtain the specimen for the Middlesex Hospital Museum. It presented the ordinary characters of complete transposition—the cæcum and appendix however, lay at the level of the iliac crest under cover of the large *left* lobe of the liver, as they had not fully descended into the left iliac fossa.

Apart from these cases of transposition of the viscera ectopic positions of the cæcum and appendix may usually be explained under one of the following headings: (1) Arrest of their descent towards the right iliac fossa. (2) Continuation of their descent beyond the normal limit, into the pelvis or into a hernial sac. (3) Deflection to some abnormal position—usually to the left—associated with a failure in the adhesion of the cæcum and ascending colon to the posterior wall of the abdomen and retention of the primitive dorsal mesentery.

In addition to the above-mentioned congenital causes of ectopia, displacement may occur as the result of a loaded cæcum, giving rise to a low pelvic position, and other pathological conditions such as visceroptosis.

In concluding this account the authors consider that a brief reference is necessary to the statistics dealing with the position of the appendix by previous observers, which appear to differ markedly from their own series. In some cases this may be explained by different methods of classification. For example, M. Laffoigue (*Anatomie Humaine*, Testut), from an examination of 290 cases of all ages and both sexes, records the following percentage of frequencies—

Ascending type	13	per cent
Descending type	41.5	,
Lateral and internal type	26	,
Lateral and external type	17	,
	<hr/>	
	97.5	,

Of his atypical rare cases, the appendix was twisted round the ileum in one case, and round the cæcum in another.

The classification is here based on the direction of the tip or longitudinal axis of the appendix, rather than on its position relative to the ileum cæcum, pelvic brim, or peritoneal fossæ. In comparing these figures with the author's series, it is probable that the 13 per cent grouped together in Lafforgue's ascending type would have included, in addition to the author's, pre-ileal and 'splenic' or post-ileal types a considerable number of the post-cæcal and retrocolic cases in which the tip of the appendix happened to have been directed upwards in a retrocolic fossa. The descending type (41.5 per cent) would have included, in addition to the author's 'pelvic' or descending type, a certain number of the sub-cæcal and post-cæcal types. The discrepancy therefore, is obviously not so great as might be supposed.

From the clinical standpoint, however, the classification of the position of the appendix adopted in this article appears to be the more practical, since the appendix is often coiled or kinked (*Figs 291 and 293*), and also since, from the surgical standpoint, the relations are often essentially different. For example, an ascending pre-ileal appendix lying free in the peritoneal cavity is totally different from an ascending retrocolic appendix confined in a fossa behind the colon, or perhaps extra-peritoneal.

In conclusion we wish to emphasize the frequency with which we have found the appendix lying in the post-cæcal and retrocolic positions, namely, in 69.2 per cent of the total number of 3000 cases. We regard this therefore, as the typical and most common position of the appendix, and the descending or 'pelvic' type as the next in order of frequency.

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SOME POINTS IN THE SURGERY OF THE PITUITARY GLAND.

By PERCY SARGENT London

(1 Contribution to the Discussion upon the Surgery of the Endocrine Glands at a Meeting of the Sixth Congress of the International Society of Surgery, held in London in July, 1923)

Few things in medicine are more striking than the interest which during the past few years, has been excited by the endocrine glands. The mystery of their functioning and the fascinating therapeutic possibilities which increasing

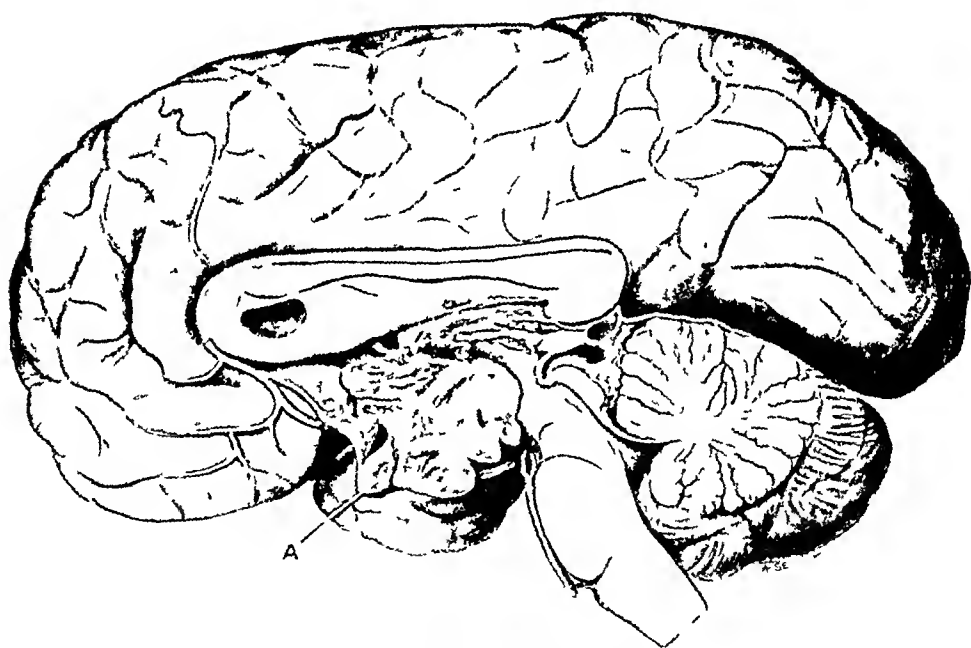


FIG. 303.—Case 23. Infundibular tumour displacing the optic chiasma downwards, attached to the floor of the third ventricle and appearing to arise from the upper part of the infundibulum. Except at its attachment it was surrounded by a capsule. It was semi-cystic and contained yellow albuminous fluid with numerous cholesterol crystals and some calcareous matter. The sella turcica was greatly enlarged; the pituitary body was of normal size though flattened. The patient was an undersized boy 10 years of age with partial bitemporal hemianopia and papilloedema. A simple decompression was followed by great general improvement and increase of visual acuity. A month later the tumour was exposed, and partially removed, but death occurred within a few hours. A. Optic nerve.

knowledge suggests, strike the imagination in a peculiar manner. The testicle, under the euphemism of 'monkey gland', figures in dinner-table conversation, rejuvenation by some unspecified hormonal means has formed

the basis of a recent novel, and manufacturing chemists compete with one another in advertising elixirs distilled from any and every internal organ. Although speculation has far outstripped knowledge the past few years have nevertheless been marked by a substantial accumulation of facts regarding the physiology of the normal and the pathology of the diseased endocrine glands, and in this advance surgery has had its share. The operative treatment of exophthalmic goitre for instance, although many questions connected with it are still unsettled, has been established upon a firm footing. The same cannot, however, be said at present of the surgery of the pituitary gland. Although there exist many resemblances between the thyroid and

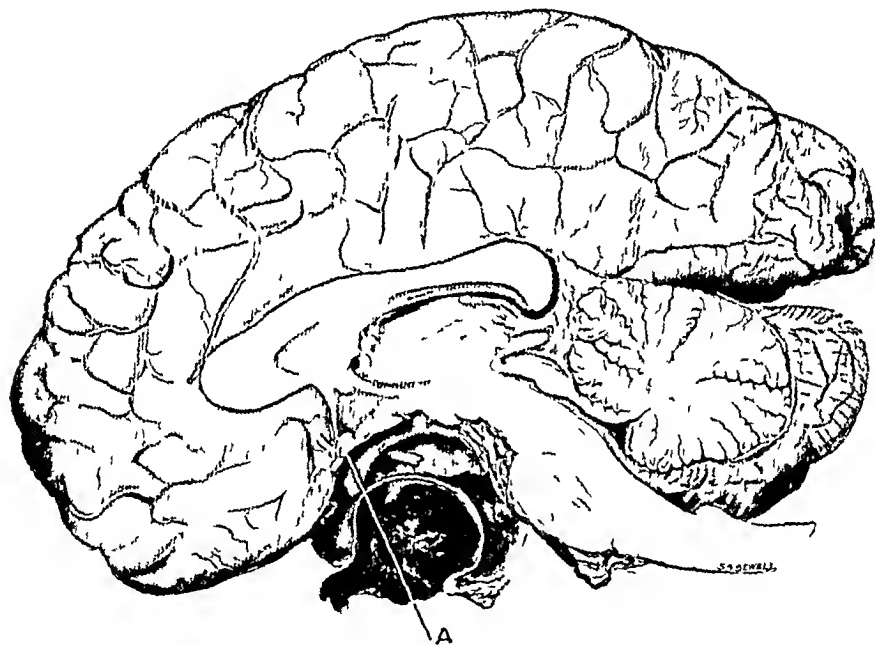


FIG. 304.—Case 26. Adenoma. The patient was a man 25 years of age who complained of failing vision for two years. Hypopituitary symptoms had commenced a year earlier. The left eye was blind and only a small part of the nasal field of the right eye remained. Frequent severe headaches. A large amount of soft tumour was removed and all went well until pneumonia supervened, from which death occurred on the twelfth day. The tumour has been pulled down wards to show the position of the optic chiasma and tract. A. Optic chiasma.

the pituitary, the comparison must not be pressed too far, and certainly from the surgical point of view the two glands must be approached differently. Each, when diseased may cause two distinct groups of symptoms, those due to disordered function and those due to enlargement. But whilst an enlarged thyroid sometimes requires surgical measures for the relief of dyspnoea, it is far more often operated upon either for cosmetic reasons or because of glandular symptoms. The pituitary on the other hand causes serious pressure symptoms which call for relief quite apart from any functioning of the gland, and, indeed, few operations can ever have been performed

for the relief of dyspituitarism unaccompanied by any other symptoms. Cushing¹ relates a case in which glandular symptoms were considerably modified after a pituitary operation of this kind. The patient was a male acromegalic with a history extending over eight years. A partial removal of the pars anterior by the nasal route was followed by immediate cessation of the headaches and three months later there was a well-marked change in the patient's appearance. When we are dealing with cases which are at the present time conveniently regarded as hypopituitarism it is possible that an operation which relieved pressure upon any remaining normal gland tissue by emptying a cyst by removing a mass of adenomatous tissue or by merely

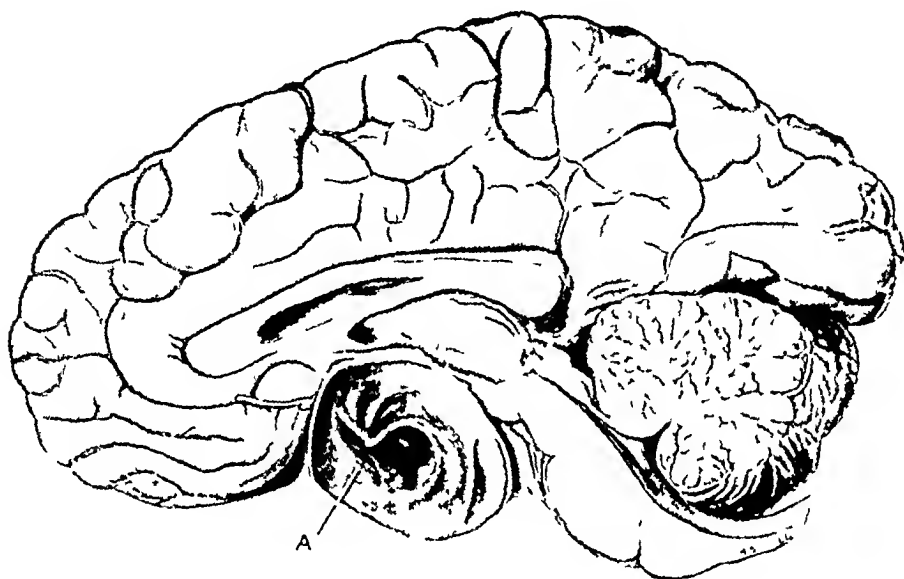


FIG. 105.—Case 15. An infundibular cholesterol cyst. The patient was a girl 18 years of age exhibiting well marked 'hypopituitary' symptoms. Headache and visual deterioration had been noticed for two years. The cyst was emptied by aspiration. She died twelve days later having exhibited remarkable toxic symptoms since operation. She was restless, talking incessantly and at times maniacal; the temperature remained high reaching 106° and an urticarial rash appeared. Post mortem the cyst was attached to the base of the infundibulum and floor of the third ventricle, whilst the optic chiasma and nerves were displaced downwards. A. Optic nerve.

incising the dual capsule, might be beneficial. I have indeed seen a remarkable improvement in appearance take place several years after the emptying of a pituitary cyst in a man who exhibited a mixture of symptoms of acromegaly and infantilism, but whether the improvement is to be attributed to the effects of the operation, or to some obscure spontaneous changes it is impossible to say.

Up to the present, surgery has been little concerned with the functional vagaries of the pituitary gland, except in so far as they may assist in the diagnosis of gross pituitary disease. Possibly in the future the hyperactive gland may be removed, as is now the practice in the case of the thyroid for Graves' disease, or pituitary glands may be successfully grafted into the subjects of hypopituitarism, but at present the chief concern of surgical

intervention as regards the pituitary is to relieve symptoms of local or general pressure caused by tumours or other enlargements of the gland

So hazardous are pituitary operations that, if anything is to emerge as regards surgical intervention for glandular symptoms it must do so as a

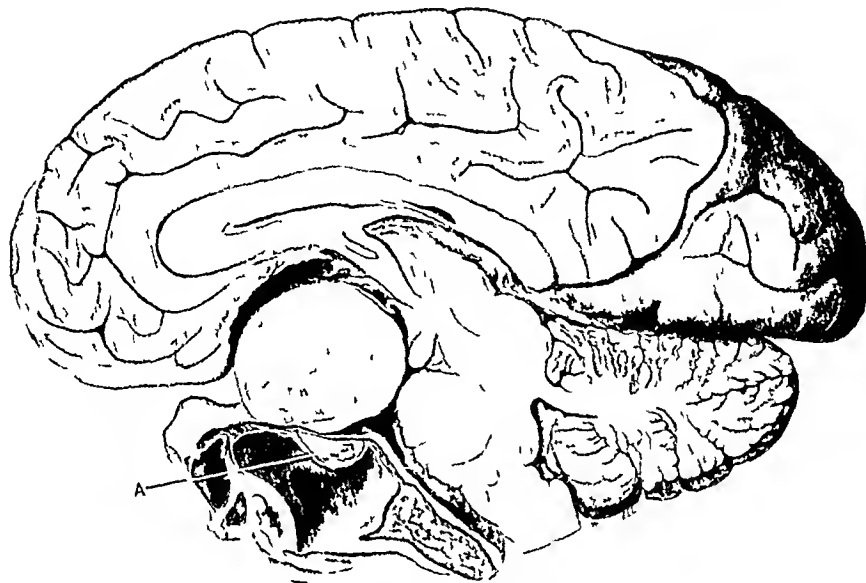


FIG. 306—Case 1. Suprapituitary endotheioma (*Specimen 14522 R.C.S. Museum*). The patient was a man 41 years of age, who had been under observation for eleven years for failing vision. He became completely blind in the left eye in about three months and in the right eye in about ten years after the onset of symptoms. No other symptoms local or glandular were observed until the onset of the general pressure symptoms some three months before death. The chiasma and optic nerves were stretched over the tumour, which was spherical and 2 cm. in diameter. It was only loosely connected with the meninges. A Pituitary gland.



FIG. 307—*Specimen 17331 P.C.S. Museum*. Left lateral view of a lobulated carcinoma from a man 35 years of age (*St. Charles Ballance's case*) with a history of loss of vision and persistent headache for a period of five months. The right eye was quite blind and the temporal field of the left was lost. No definite glandular symptoms were observed. A Left 3rd nerve. B Left optic nerve. C Right 5th nerve.

by-product of such operations as are rendered justifiable by threatened blindness and intolerable headache. In the present state of our knowledge the surgery of the pituitary must concern itself primarily with the relief of pressure symptoms caused by tumours or other diseased conditions accompanied

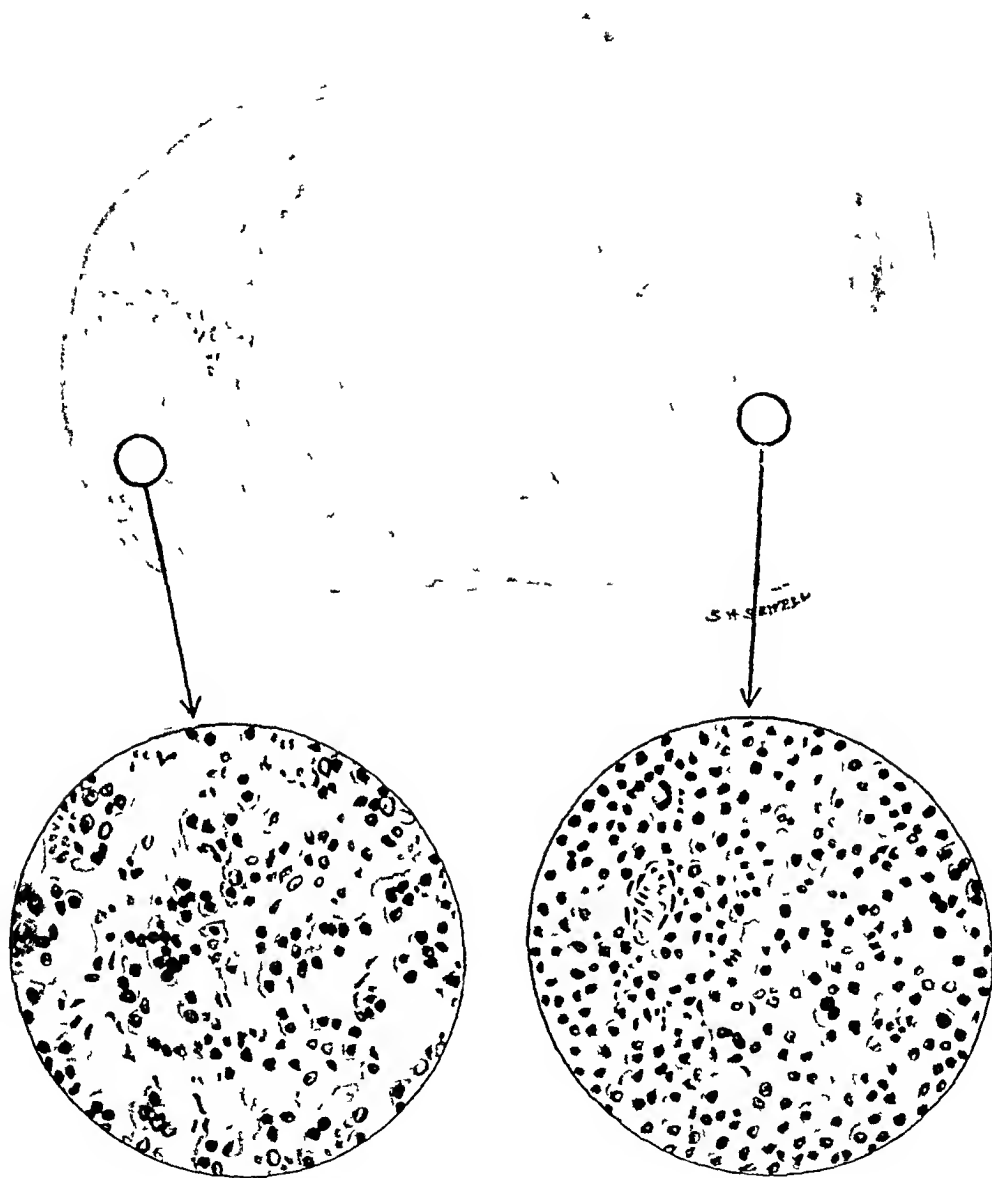


FIG 308—A minute intrapituitary adenoma

A Coronal section through the whole gland ($\times 10$). The gland measured $15 \times 10 \times 10$ mm. Shows adenoma replacing substance of pars anterior, a small crescent of which is seen to the left. The whole mass is intrasellar and surrounded by the dural capsule.

B Section of normal part of gland ($\times 500$) showing both oxyphil and basophil cells, and extreme vascularity.

C Section of the adenoma ($\times 500$). The cells resemble in type the oxyphil cells of the normal gland, but take the eosin stain less intensely.

by enlargement of the gland and I intend here to confine myself to a brief inquiry based upon my personal experience

Symptoms of pressure caused by pituitary enlargements are conveniently grouped as local and general. Any increase in the general intracranial pressure is to be regarded as of serious import because it indicates that the intracranial extension of the tumour is large enough to cause an obstructive hydrocephalus. It also adds greatly to the dangers and difficulties of a direct attack upon the enlarged gland. When such symptoms are present and the pressure is not of so high a grade that a fatal termination is inevitable a simple decompressive operation in the temporal region is capable of affording a considerable degree of relief. Thus, however, must be regarded merely as a palliative operation, as in any other case of inmovable intracranial tumour, but with this difference, that it cannot be expected to relieve the headache which results from tension within the pituitary capsule nor to benefit vision. It may also be employed as a preliminary measure to facilitate a subsequent frontal operation.



FIG. 309.—Specimen 481 R.C.S. Museum. From an acromegalic female 41 years of age. The tumour described as 'histologically resembling the pars anterior of the normal gland' measures 6.5 cm. in the vertical direction; the intracranial portion has an antero-posterior diameter of 5 cm. (Reported by J. B. Neal and S. G. Shattock *Trans. Pathol. Soc. Lond.*, 1898, xlv.)

It is in the relief of symptoms due to local pressure that most is to be expected from surgical intervention. I may say at once that, so far as my own experience goes, the term 'removal' used in connection with pituitary tumours has always meant 'partial removal'. I had until quite recently never encountered a case or seen a specimen in which total removal could by any possibility have been effected during life. (See Figs 303 to 307.) The solitary possible exception is the case of a minute intrapituitary adenoma illustrated in Fig 308. In this instance I had set out to remove part of the contents of the sella turcica and had not a severe hæmorrhage unfortunately compelled me to abandon the operation. I should probably have succeeded in removing this tumour.

The two outstanding pressure symptoms which can be relieved by operation upon the enlarged gland or upon tumours in its immediate vicinity are

visual deterioration and headache whether that headache be of the peculiar frontal paroxysmal 'bursting' type which has been called 'pituitary headache' or of the more ordinary character dependent upon a general rise of intracranial pressure. It is my present opinion that progressive visual deterioration and severe headache are the only symptoms which justify a surgical attack upon a pituitary tumour. When an operation is being planned it must be remembered that the size of the sella turcica as indicated radiographically gives no information as to the total size of the pituitary enlargement, and further that by the time the visual symptoms are at all pronounced, the bulk of the tumour within the cranial cavity is usually greater than that portion which lies within the sella turcica (*Fig. 309*). The increased intracranial pressure which results from this extrasellar extension is a factor of supreme importance from the operative standpoint. This fact should be given due consideration when the methods of approach are being weighed.

During the past few years I have operated upon 38 patients for pituitary disease, actual or supposed. The number is too small to permit of any but the most tentative conclusions, and even those who indulge in the fallacious practice of expressing surgical results in mathematical terms would derive little satisfaction from so meagre a list. On the other hand, the number is not too large to prevent all the cases being briefly tabulated and it is in this form that I have set forth the main facts concerning them.

ANALYSIS OF 38 CASES OPERATED UPON

I 17 CASES OF 'ADENOMA' OR 'HYPERPLASIA OF PARS ANTERIOR'

4 Trans-sphenoidal Operations with Partial Removal —

- Case 2* —M, 20 Considerable improvement (died of pneumonia 15 months later)
Case 3 —M, 21 Very great improvement in every way, especially visual (Lost trace of after 6 months owing to war. Patient was a German clerk.)
Case 11 —M, 25 Temporary improvement in headache and vision. Relapse a few months later. Temporal decompression followed by improvement.
Case 14 —M, 38 —Died of meningitis.

9 Frontal Operations with Partial Removal —

- Case 8* —M, 35 Died within a few hours.
Case 18 —M, 34 Died within 24 hours.
Case 20 —F, 48 Very great improvement. Well 2 years later.
Case 21 —M, 21 Very great improvement. Well 2 years later.
Case 24 —M, 30 Died within a few hours.
Case 25 —M, 40 Excellent recovery. Died of pneumonia 4 months later.
Case 26 —M, 35 Died of pneumonia a week later.
Case 27 —F, 50 Died next day.
Case 38 —F, 48 Excellent recovery. Recent case.

3 Frontal Operations without any Removal of Tumour —

- Case 5* —M, 23 Fatal hæmorrhage from circle of Willis during operation.
Case 30 —M, 31 Abandoned as a simple decompression on account of general pressure. Good recovery.
Case 37 —F, 41 Fatal hæmorrhage during operation.

1 Temporal Operation —

- Case 22* —M, 40 Simple decompression. Improved in all respects and resumed work (clerk).

II 11 CASES OF SUPRAPITUITARY TUMOUR (Endothelioma 5, Cholesterol cyst 3, Infundibular tumour 3)

a 5 *Endothelioma*—

- Case 1—M, 41 Bitemporal decompression when *in extremis* Died
 Case 6—M, 30 Frontal operation—partial removal—excellent recovery Lost trace of owing to war (German musician)
 Case 16—M, 42 Temporal decompression—improved Survived 3 years
 Case 31—F, 49 Frontal operation—partial removal—excellent recovery Well 11 months later
 Case 32—F, 12 Frontal operation—partial removal—excellent recovery Well 6 months later

b 3 *Infundibular Tumours*—

- Case 7—F, 25 Frontal operation—partial removal Died 10 days later (Ganglio-neuroma)
 Case 10—F, 35 Temporal decompression Died soon after operation (Ependymal tumour)
 Case 23—M, 10 Temporal decompression followed later by frontal exploration Died soon after operation (Ependymal tumour)

c 3 *Cholesterol Cysts*—

- Case 15—F, 18 Frontal operation—evacuation Died 12 days later (Meningeal)
 Case 19—M, 54 Temporal operation—evacuation Died 2 months later
 Case 28—M, 39 Temporal operation—evacuation Died 3 years later (Insane)

III 4 CASES OF 'CYSTIC SEROUS MENINGITIS'

- Case 12—M, 49 Frontal operation Three years later quite well Vision better
 Case 13—F, 36 Frontal operation Much improved Died 3 years later (? cause)
 Case 17—M, 36 Temporal operation Improved Alive 3 years later
 Case 36—F, 31 Frontal operation Back to work Well 6 months later

IV 6 CASES WRONGLY DIAGNOSED

- Case 29—F 36 *Frontal endothelioma* Frontal exploration No improvement Died 2 months later
 Case 34—M, 31 *Frontal glioma* Nasal operation Died in coma a week later
 Case 35—F, 13 *Frontal glioma* compressing pituitary Temporal decompression Relief Died 10 months later
 Case 33—F, 12 *Mesencephalic glioma hydrocephalus* Nasal operation Died of meningitis
 Case 4—M, 53 *Arteriosclerosis, optic atrophy* Frontal exploration Died 6 years later Post mortem, no other lesion
 Case 9—M, 27 *No gross lesion* Frontal exploration Atrophied optic nerve Alive 5 years later—periodic headaches

If so far the tale is a disheartening one, we have to remember that many of the failures can be traced to causes which subsequent experience has shown to be preventable and that a much larger proportion of good results can be confidently expected when we have learnt to minimize mistakes of diagnosis, judgement and technique. Even such simple operations as prostatectomy have passed through a period of excessive mortality. We must remember, too, that many of these patients suffer from a number of distressing symptoms which often render life insupportable and from a disease which, after causing complete blindness, will ultimately prove fatal, so that even a few strikingly good results although they may concern but a small proportion of the whole are not to be despised. I feel confident that with better

judgment in the selection of cases with increasingly improved operative technique and above all perhaps by operating at a much earlier stage in the evolution of the disease it will be possible to benefit a far larger percentage of these unfortunate patients. In this connection the following case (*Case 37*) is of special interest. It shows that with intrasellar growths it may be possible to make the diagnosis when the tumour is still small and confined within the sella before any conspicuous enlargement of the sella has occurred and before the general intracranial pressure is raised. It also shows that considerable restriction of the visual fields may occur from very slight upward bulging of the diaphragma sellæ. Had it not been for an unfortunate operative accident there is every reason to believe that the little tumour would have been removed completely and that the result as regards headache and vision and perhaps also as regards the glandular symptoms would have been good.

Case 37—The patient a female, 41 years of age, had suffered for ten years from severe headaches, and had noticed her hands getting larger. Disturbance of vision was first noticed about six months before her admission to hospital. For some years the headaches had been related to the menstrual periods and had been chiefly frontal. The hands and feet had gradually enlarged, and the facial appearance had altered. On admission, the visual fields were found to be greatly diminished concentrically, that for green being the smallest and that for the white the largest, the red field being intermediate in size. The optic discs were normal. X-ray examination showed no enlargement of the sella. No operation was advised and she left the hospital. She was re-admitted four months later the headache having become intolerable, and now frequently accompanied by vomiting. The visual fields had become much smaller concentrically and still showed no quadrant or hemianopia defect. The optic discs were slightly paler than normal. A trace of sugar had appeared in the urine.

A frontal osteoplastic exploration was carried out, and the pituitary region inspected. There appeared to be no bulging from the fossa. The diaphragma sellæ was incised, so as to relieve tension. Recovery was uneventful and the headache was completely relieved. Headache began again after six weeks' complete freedom, and the patient returned to hospital six months after operation. The headache had again become extremely severe, but visual acuity had improved to $\frac{6}{6}$, and the fields were a good deal larger. The discs appeared normal, and there was no glycosuria. It was determined to remove part of the contents of the sella tuncica, and the region was again exposed through the osteoplastic opening. Unfortunately hemorrhage, from a source which could not afterwards be traced, necessitated abandoning the operation. Death occurred within a few hours.

Post mortem, the pituitary gland was removed, and found to be scarcely if at all enlarged. It contained a minute adenoma (*Fig 308*).

Selection of Cases—If we are to avoid operating upon unsuitable cases we must in the first instance seek to improve our diagnosis. Many conditions cause symptoms which may be reasonably yet wrongly ascribed to pituitary lesions. No fewer than 6 of my 38 cases belong to this class, three were cases of tumour of the frontal lobe causing visual deterioration from pressure upon the optic nerve, or chiasma, with disturbance of function from pressure upon the pituitary gland, one was a mesencephalic glioma which gave no localizing signs, but which by causing ventricular distention produced enlargement of the sella and symptoms of hypopituitarism, two were cases of optic atrophy without gross lesion, in which the operation was of a purely exploratory character. They illustrate some of the difficulties of diagnosis, and the cases

in which no gross lesion was found are also interesting as demonstrating with what ease and safety the infundibular region can be explored by the frontal route

In a large proportion of cases however, the diagnosis of pituitary tumour can be made with precision and at an early stage, but unfortunately the nature and extent of the lesion cannot always be accurately diagnosed. At present, therefore many of our operations must necessarily be of an exploratory character. Even when exposed the full extent of the tumour can rarely be ascertained accurately. In several cases in which I was able to remove a considerable quantity of tumour tissue subsequent post-mortem examination showed that the extent of the growth was such as to defeat any surgical attack upon it. In some such cases had an accurate diagnosis of its extent been possible beforehand, I should have realized that a simple decompressive operation was the only possible surgical procedure. Even in cases of simple pituitary adenoma, with great enlargement of the sella, the diagnosis of which is usually easy, it is impossible to estimate the extent of the intracranial portion of the tumour.

Causes of Failure—Operations for pituitary tumour are so hedged about with dangers and difficulties that the patient who successfully runs the gauntlet

may indeed be accounted fortunate. Quite apart from the local difficulties which may be encountered the general physical condition of the patients is usually such that they support very badly surgical procedures of any magnitude, whilst they seem to be conspicuously lacking in resistance to infection, and are therefore liable to succumb to pneumonia.

Further, it is unfortunately true that by the time the patient is submitted to operation the general intracranial pressure is often so great that the physical difficulty of approaching the pituitary region may be insurmountable, even with the assistance of a previous decompressive operation or of lumbar or ventricular puncture. The degree of this increased intracranial pressure is more difficult to estimate beforehand than in the case of tumours elsewhere in the brain because, owing

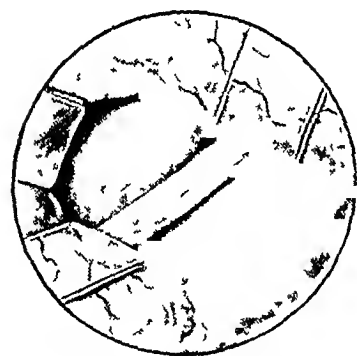


FIG 310.—Case 28. From a sketch made during operation. Shows a large suprapituitary cholesterol cyst exposed by the temporal route with the optic nerve stretched over it and displaced downwards and forwards.

to the direct pressure upon the optic nerves, we are denied the information which in other cases we derive from measuring the degree of papilloedema.

There is yet another source of failure which I have observed, and which I believe to be of great importance, and it is perhaps in some measure comparable to one of the causes of death after operation for exophthalmic goitre. The escape of toxic material from the tumour into the cerebrospinal fluid both during and after operation, seems to be capable of producing grave and even fatal symptoms. Thus I think is especially true in the case of cysts containing cholesterol. I now seek to avoid this complication in two ways, first, by removing the contents of the tumour capsule by aspiration, and

secondly by sealing the opening in the capsule with a muscle-graft before completing the operation

The causes of failure then so far as my own experience teaches, may be summed up as follows (1) Errors of diagnosis leading to misdirected operations, (2) Massive intracranial extension of the tumour rendering the case unsuitable for any operation except a palliative decompression, (3) Operative accident, (4) Post-operative pituitary toxæmia, (5) Post-operative pneumonia, (6) In trans-sphenoidal operations septic infection

Methods of Approach

—The many methods of surgical attack which have from time to time been devised may be regarded as falling into two groups

the *extradural*, embracing transpalatal, nasal, and paranasal operations and the *intradural*, comprising the temporal and frontal Hoisley, who in 1906 had already operated upon nine cases, strongly favoured the temporal route. At that date he wrote, in characteristic fashion, "The prehistoric way of

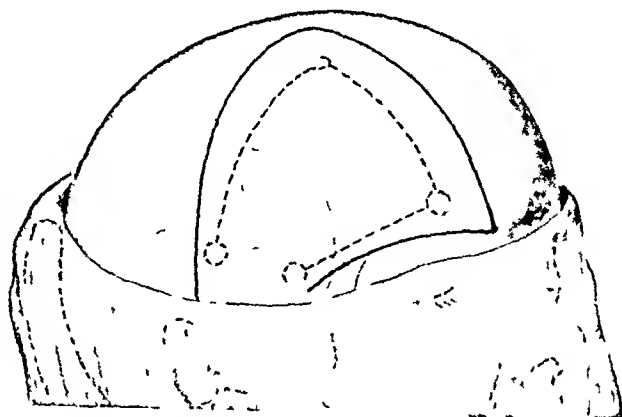


FIG 311—Outlines of osteoplastic flap for frontal approach (modified Frazier operation)

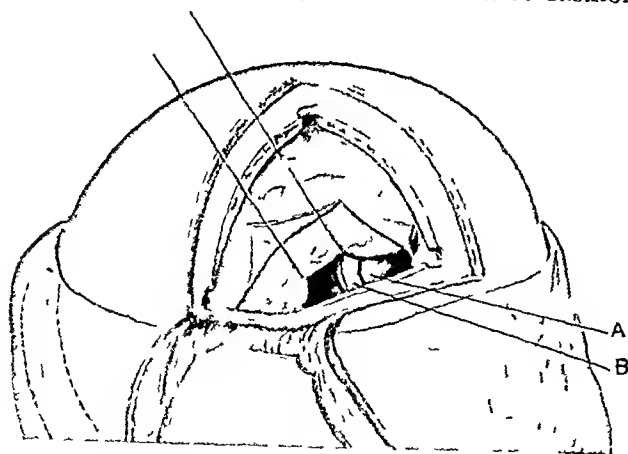


FIG 312—Exposure of tumour by frontal osteoplastic approach A Tumour B Optic nerve and ophthalmic artery

operation, and in two others some aphasia and hemiparesis. It is clear that in elevating the temporal lobe there is more risk of damaging important areas of the brain than in elevating the frontal lobe. The temporal route however, may sometimes be the method of choice, particularly when the chief object aimed at is a general decompressive effect (Fig 310)

raising the frontal lobe is not the proper way to remove the tumour, it should be done by raising the temporal lobe." The records of the National Hospital, Queen Square, include only four cases operated upon by Hoisley between the years 1902 and 1911, one patient died shortly after the operation, one lived nine months, another three years, and another eight years. In two of them some degree of ophthalmoplegia followed the

The intradural route which I have found to give a perfectly satisfactory approach to the sella turcica is a modification of the osteoplastic orbito-frontal method of Frazier. The only real difference between this and the original Frazier operation is that I make a much larger osteoplastic flap, so as to render interference with the orbit and supra-orbital ridge unnecessary. Even in the thick and bossy acromegalic skull I find no difficulty in reaching the interpenduncular space without removing the supra-orbital ridge (*Figs 311, 312*).

Of the extradural methods of approach the only one of which I have had any personal experience is the trans-sphenoidal operation of Cushing, and this is a very small experience, including but six cases. Although one of these was attended by an excellent immediate result, particularly as regards vision, and two others might be regarded as satisfactory results, yet I cannot bring myself to feel that it is the best method. Its chief attractions are that it is a comparatively easy operation, and is one which patients of poor stamina, as these usually are, can easily support further, the likelihood of causing the pituitary toxæmia to which I have referred is almost if not completely abolished. But it is not free from the dangers of septic infection, and as so little can be accomplished through so small an opening, the beneficial effects are likely to be meagre and transient. It is, moreover, only applicable to cases of pituitary tumour in which the sella turcica is conspicuously enlarged, no information can be gained as to the extent of the intracranial extension, and no general decompressive effect can be obtained. The frontal operation on the other hand, allows of thorough exploration, of partial removal of the intracranial extension of dealing with suprapituitary tumours and other lesions in the neighbourhood, and of some measure at least of general decompression, whilst it is free from the dangers of septic infection.

SUMMARY

Operations for pituitary tumour are only justified as a means of relieving headache or averting blindness.

Tumours are rarely if ever capable of complete removal.

The choice of operative approach lies between the trans-sphenoidal method of Cushing, the frontal route of Frazier, and the temporal route of Horsley. The first-named is comparatively easy and attended by a low mortality-rate, but its field of usefulness is limited to one type of pituitary tumour in which the sella turcica is considerably enlarged, the second gives better access, and can be used for all varieties of lesion in or near the pituitary gland, the third is useful for cases in which the general intracranial pressure is high.

REFERENCES

- ¹ CUSHING, *The Pituitary Body and its Disorders*, 1912
- ² HORSLEY, *Brit Med Jour*, 1906, Feb 10

TRANSPLANTATION OF THE TENSOR FASCIÆ FEMORIS IN CASES OF PARALYSIS OF THE QUADRICEPS MUSCLE

By NAUGHTON DUNN AND I. WILSON STUART BIRMINGHAM

In the upper extremity the action of individual muscles is highly specialized. In this case re-education allows us to utilize individual muscles effectively when dissociated by transplantation from the group with which they are normally in action.

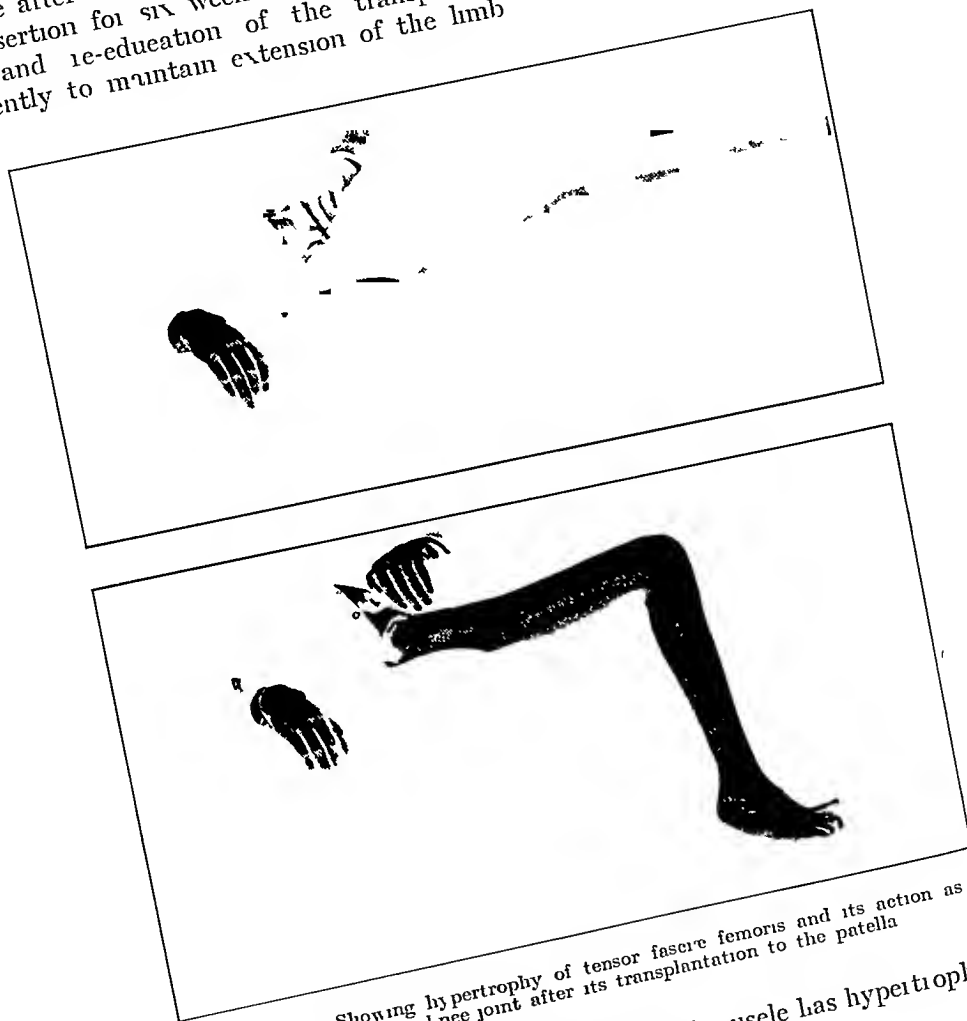
In the lower extremity the movements of the joints in propulsion of the body are automatic, and are controlled by strong muscle groups. It is therefore difficult to re-educate an individual muscle to act apart from the group with which it is normally in action. This we believe explains the failure of the peroneus longus to replace a paralysed tibialis anticus, and of the transplanted biceps tendon effectively to replace a paralysed quadriceps.

A safe clinical test in the selection of tendons for successful transplantation in the lower extremity is that the muscles transplanted should be those used by the patient in his effort to replace the action of the paralysed muscle. In an appreciable number of cases of infantile paralysis power of extending the knee-joint is lost, while definite power is present in the sartorius and (or) the tensor fasciæ femoris. If such a patient is asked to extend his knee-joint one or both of these muscles will tighten and the external or internal rotation of the limb will depend on the relative power in these. Both will make an effort to replace the action of the quadriceps. By altering then insertion to the patella then effort becomes effective.

Attention has already been drawn to the results of transplantation of the sartorius where this muscle is active in the presence of quadriceps paralysis. We now wish to record two cases in which the tensor fasciæ femoris has been successfully utilized by transplantation as an effective extensor of the knee-joint.

OPERATION—A skin incision is made from the anterior superior iliac spine along the outer aspect of the thigh to just below the knee-joint, where it curves across the limb. Flaps are raised on either side the anterior one sufficiently to allow exposure of the patella. The anterior and posterior borders of the tensor fasciæ femoris and the iliotibial band throughout its length are exposed. The anterior and posterior borders of the tensor fasciæ femoris are defined. From these borders two incisions extend downwards to the knee-joint, giving a breadth of fascia lata equal to the breadth of the muscle at its insertion. This long ribbon of fascia and muscle is fixed and transplanted to the quadriceps tendon and the patella. The points to which special importance is attached are that its course from origin to insertion should be a direct one and that it should be safely sutured under tension.

The after-treatment is also important. No strain should be put on the new insertion for six weeks. A caliper splint is worn until electrical treatment and re-education of the transplanted muscle have developed it sufficiently to maintain extension of the limb.



FIGS 313 314—Showing hypertrophy of tensor fasciae femoris and its action as an extensor of the knee joint after its transplantation to the patella

In both the cases reported the transplanted muscle has hypertrophied, and active extension of the knee-joint by it is now possible

THE REMOTE RESULTS OF OPERATIONS FOR INJURIES OF THE PERIPHERAL NERVES

By HARRY PLATT, MANCHESTER, AND W. ROWLEY BRISTOW, LONDON

SUMMARY

INTRODUCTION

PATHOLOGICAL CONSIDERATIONS

- 1 The pathogenesis of nerve injuries
- 2 The distant effects of a nerve injury
- 3 Associated lesions

PRINCIPLES OF OPERATIVE TECHNIQUE

- 1 Difficulties in effecting repair
- 2 Technique of nerve suture

CLINICAL CONSIDERATIONS

RESULTS OF OPERATIONS FOR THE REPAIR OF NERVE INJURIES

- I—Methods of estimation
- II—Operations for the restoration of conduction
 - 1 Statistics
 - 2 Results of end-to-end suture
 - 3 Results of neurolysis
 - 4 Bridge operations
- III—Operations for the relief of pain and other irritative phenomena
- IV—Operations designed to restore function in irreparable lesions or in cases of incomplete recovery

SUMMARY

BIBLIOGRAPHY AND REFERENCES

INTRODUCTION

It is inevitable at this date that an inquiry into the remote results of operations for injuries of peripheral nerve-trunks should be dominated almost exclusively by the experience acquired in recent years in connection with the reconstructive surgery of the great war. From the unprecedented amount of material which has been under observation during this period much information has been gleaned, and the knowledge thus obtained has been widely disseminated. A most extensive literature has now accumulated around the subject but it must be admitted—in this country at least—that few statistics dealing with true end-results on a large scale have been forthcoming. For a considerable time, surgeons interested in this problem had the advantage

* This paper represents the British Report on this subject presented at the meeting of the International Association of Surgery in London on July 19, 1923.

of retaining in special hospitals large numbers of patients who were suffering from gunshot injuries of nerves. These patients have now been scattered far and wide, and many are no longer undergoing active treatment or rarely come under expert observation. During the past two years it has become increasingly difficult to add to those records already in our possession, which so far have illustrated little more than interim results.

The traumatic lesions of nerves which occur in civil life, and more particularly the type of injury in which end-to-end suture is demanded do not ordinarily fall into the hands of individual surgeons in great numbers. Since the appearance of the monograph of Sherren in 1908, nothing has been added to the broad principles there formulated in regard to the results to be obtained after suture operations. But the past decade has seen a definite expansion and crystallization of our knowledge concerning the exact pathogenesis and the results of the surgical treatment of certain familiar nerve lesions belonging to the 'compression' class. These are (1) The traumatic neuritis affecting the lower trunks of the *brachial plexus*, induced by a supernumerary cervical rib, or under certain conditions by a normal first dorsal rib, and (2) Traumatic neuritis of the *ulnar nerve* in the region of the elbow, developing after a latent period as the result of a fracture of the external condyle of the humerus in early life—the so-called 'late involvement' of this nerve. A detailed consideration of these special types of nerve injury does not concern us here. The surgical treatment of such lesions, however, illustrates very clearly the rationale of those operative procedures which are classed under the heading of *neurolysis*. In discussing the results of neurolysis in the case of gunshot lesions, passing reference will be made to these civil compression lesions for the purpose of comparison only. The report to be presented by the writers will thus deal with the results of operations performed for gunshot injuries alone.

Before proceeding to introduce this subject in its more limited sense, it is advisable to review briefly certain fundamental considerations which have an essential bearing on the study of the various factors which may determine the success or failure of any form of operative repair.

PATHOLOGICAL CONSIDERATIONS

1 The Pathogenesis of Nerve Injuries—The characteristic pathological anatomy of the nerve lesions of warfare is now so widely known that it is unnecessary to do more than stress certain outstanding features.

In the vast majority of instances the nerve injury belongs to the 'primary' class and gross destruction with immediate loss of anatomical continuity is frequently seen. To the primary destructive effect of the missile is added the influence of a second potent factor—wound infection. Further destruction of nerve tissue now takes place in the course of the acute inflammatory reaction which follows. With the onset of the phase of healing and the

* The authors have reviewed all the available literature on this subject published in the various countries during recent years, and the information thus derived is embodied in their general criticisms and conclusions. The statistics reproduced however, have been deliberately limited to those issued from the various British surgical centres.

production of young scar tissue there is seen a still further obliteration of nerve substance. Finally the scar tissue when fully matured has built up an impenetrable barrier which effectively prevents the growing axon of the proximal stump from obtaining access to the distal stump. These are the grosser mechanical results of wound infection. But the nerve sustains a more insidious type of damage during the time that it lies bathed in the inflammatory exudates. Bacteria and their toxins pass into the interior of the nerve-trunk and ascend for some distance above the limits of the initial lesion. The result is the development of an interstitial neuritis, the final histological picture showing a fibrosis involving the connective-tissue framework between the nerve bundles and around the individual nerve-fibres. Ascending neuritis of this type has been traced in injured nerves for many inches above the original lesion and there is evidence to suggest that this process may occasionally reach the spinal roots. In the type of nerve injury in which there is little or no anatomical loss of substance intraneural fibrosis in the proximal part of the nerve is often a dominating feature of the lesion. It is a well-established fact that an extensive interstitial neuritis exerts an inhibitory influence on the regenerative process, and further, if regeneration occurs, the symptoms of severe irritation may appear during the early stages of sensory recovery.

The fully-matured lesion as seen during an exploratory operation represents a composite histological picture, to which the primary injury, the effects of wound infection, and the attempts at spontaneous repair on the part of the nerve have all contributed. A classification of lesions based on operation records alone can therefore have no exact anatomical or pathological basis. At the same time, a recognition of certain standard naked-eye appearances is useful for descriptive purposes. Broadly, we may recognize three main types: (1) Complete division with a gap, (2) Complete division without a gap—in this form the nerve-trunk retains a pseudo-continuity, (3) The nerve-trunk is apparently intact, but presents a wide variety of local alterations in contour, size and consistence. A familiar example is the nerve 'spindle' or fusiform 'neuroma'.

2 The Distant Effects of a Nerve Injury—

a Central Changes—The significance of those early retrogressive changes which take place in the central spinal cells when the continuity of the axis cylinders is interrupted should not be overlooked. These changes are known to be most marked when the nerve injury is extensive, and particularly when the lesion is situated high up on the proximal course of the nerve. It is generally believed that the long-continued existence of a peripheral block to regeneration is always associated with the production of permanent degenerative changes in the controlling nerve-cells. This is one factor which, in combination with others, may help to determine the imperfect results seen in nerve sutures performed after long periods of delay. But the reparative capacity inherent in these cells would appear to be highly developed, for, in cases of resection and resuture performed as long as three years after the failure of a preliminary suture, recovery of the average type and degree has been seen (Stopford¹).

b Peripheral Changes—The changes affecting the tissues to which the

ultimate nerve-fibres are distributed are of two types (1) Simple *disuse atrophy* such as is seen best of all in the muscle bellies, and which is the direct result of the severance of axis cylinders (denervation), and (2) *Trophic* changes proper, which are dependent always on the existence of some form of irritation acting on vasomotor and sensory axons which still retain their integrity. The effects of irritation are exhibited in the evolution of a widespread fibrosis in the intramuscular connective-tissue planes and in the tendon sheaths and joint capsules—a familiar morbid picture in many of the gunshot injuries of nerves and generally best marked in the hand. The intensity of these fibrotic changes is accentuated where gross infection has been present. It is to be remembered that similar fibrotic changes may follow obliteration of the main vessel of a limb even in the absence of a nerve injury (ischemia). In long-standing nerve injuries, even where the influence of infection has been negligible and where irritative signs have been conspicuously absent, a certain degree of interstitial fibrosis in the denervated muscles may be seen. But under such conditions these muscles retain for long periods an anatomical structure which after re-innervation is not incompatible with function.

3 Associated Lesions—In gunshot wounds of the limbs a nerve lesion often forms but one component of a complex injury in which there is an extensive destruction both of bone and soft parts. Here, again, the secondary effects of wound infection are to be reckoned with, for fibrotic changes develop in a quiet fashion in tendon sheaths and joint capsules in regions remote from the point of injury, owing to the transference of infection by a process of metastasis. Such changes attain their maximum intensity in the tissues of the hands and feet. The disability resulting from the nerve lesion *per se* is thus often overshadowed by the changes produced by the co-existing lesions. Such complications offer grave mechanical obstacles to the attainment of effective operative repair of the nerve injury. Moreover, where the latter procedure is followed by success in a neurological sense, very little may be added to the functional value of the limb.

PRINCIPLES OF OPERATIVE TECHNIQUE

1 Difficulties in Effecting Repair—The earlier phases of the peripheral nerve surgery of the war were to a large extent experimental, but operative methods soon became stabilized. The mechanical difficulties experienced in obtaining end-to-end apposition of the proximal and distal stumps in the case of the more extensive lesions brought into prominence for a time the question of the value of the methods of indirect repair—e.g., nerve-grafting, tubulization, etc.—procedures conveniently termed ‘bridge’ operations. In this country an unbiased study of the results of the operations falling into this category soon showed that there was no justification for their continued inclusion in the repertoire of peripheral nerve surgery. With increasing experience the number of lesions found to be unreparable by the method of direct repair steadily diminished. The difficulties encountered were surmounted in the vast majority of cases by a recourse to one or more of the following technical manoeuvres, which to-day may be regarded as standardized procedures —

a The widest anatomical exposure with the freest mobilization of the proximal and distal parts of the nerve-trunk

b The additional relaxation of the nerve afforded by appropriate alterations in the posture of the limb, e.g. bringing the limb into close contact with the body with full flexion of certain joints

c The stripping up of motor branches arising proximal to the lesion from within the nerve sheath, or where absolutely necessary the deliberate sacrifice of one or more branches

d The displacement of the nerve to a new bed in such a manner as to shorten its course, e.g. anterior displacement of the ulnar at the elbow or transference of the musculospiral to the front of the upper arm (Stiles)

e The two-stage operation in which after the fullest exposure and relaxation of the nerve, the central and distal stumps—untimmed—were drawn close together by means of stout sutures and the wound then closed. Gradual stretching of the flexed joint was begun at an early date and at the end of a fortnight or three weeks the wound was re-explored and an attempt made to complete the suture. In such cases the gap originally present was found to have diminished considerably owing to the steady traction which had been exerted on the anchored ends

f Bone shortening. This was practised in cases of co-existing ununited fractures where considerable trimming of the bone-ends was a necessary part of an operation to obtain union—e.g., in extensive musculospiral nerve lesions combined with persistent non-union of the humerus—but only very rarely under any other circumstances

2 Technique of Nerve Suture—For lesions in which end-to-end suture was indicated—whether after resection of a length of nerve or after approximation of the stumps of a nerve already divided—it was found essential to trim the ends on a generous scale in an attempt to get above the level of the grosser intraneural fibrosis. In many cases this brought the lesion perilously near the irreparable class. Resection a little short of the ideal level matters less perhaps in a nerve which contains a preponderance of motor fibres, e.g., the musculospiral, than in the case of the median or sciatic nerves with their profusion of sensory and sympathetic axons. At the line of suture the nerve-ends should be in bare contact under slight tension, without any crowding together or eversion of the fasciculi. Experience has shown that sheath sutures alone are desirable, and that a stay suture passed through the whole thickness of the nerve-trunk is best avoided. The suture material should be of the finest calibre compatible with the strain to which it is subjected. In the experimental work of Sargent and Greenfield² it has been conclusively shown that the finest linen thread (No. 160 as introduced by Stiles) is the ideal material. Catgut impregnated with chemical irritants has no place as a suture material for a divided nerve.

The protection of the line of suture by sleeves of fat, fascia, or prepared animal membranes was soon given up. Whenever possible, the nerve should be placed in a bed consisting of healthy muscle tissue. In certain regions where this is not possible, a small sheet of fascia inserted under the nerve forms the most efficient protection from denuded bone, rough callus, or bare tendons.

CLINICAL CONSIDERATIONS

Many of the older statistics dealing with the results of operations for the repair of nerve injuries must now be regarded as unreliable in the light of our present-day knowledge of the difficulty experienced in recognizing the signs of genuine recovery. Many pitfalls beset the path of the clinical observer. On the motor side there are the now well-recognized 'trick' or substitute movements which have been studied and reported in full detail by Wood Jones.³ From his account may be quoted the following examples—

1 With complete division of the *median* and *ulnar* nerves in the upper arm, flexion of the wrist may be carried out by the action of the *extensor ossis metacarpi pollicis*

2 With complete division of the *musculocutaneous* and *musculospiral* nerves in the axilla flexion of the elbow is carried out by the combined action of the *pronator radii teres* and the common flexors of the wrist and fingers

3 With complete division of the *median* and *ulnar* nerves in the upper arm, flexion of the fingers is carried out by voluntary dorsiflexion of the wrist, the paralysed tendons acting as ligaments and thus approximating the fingers to the palm

4 With complete division of the *median nerve* in the forearm, opposition of the thumb may be carried out by the combined action of the *adductores pollicis* (*ulnar*) and the *extensor ossis metacarpi pollicis* (*musculospiral*)

These and similar trick movements are often carried out quite forcibly and against the action of gravity. They have been found to vary greatly in different individuals and were not acquired by the majority of patients with nerve injuries.

On the sensory side the variations which may occur in the loss of sensibility, particularly as estimated by the appreciation of the pain of pinprick—'protopathic' sensation—are now better recognized. As an example, the variations which are met with after division of the median nerve may be quoted. The area of loss to pain generally embraces the palmar surface of the thumb, index, and middle fingers and the adjoining third of the palm but in certain individuals the area of overlap of the ulnar nerve for this form of sensation is unusually extensive. Complete division of the median in the forearm may then result in loss to pinprick over the palmar aspect of the terminal phalanx of the index and medius alone. Unless the observer recognizes these facts he will regard the appreciation of painful stimuli on this area as evidence of recovery, or incomplete division of the nerve. Such fallacies in interpretation explain the cases of preternaturally early recovery after nerve suture which from time to time are recorded in surgical literature and also many of the reported successes of nerve-grafting operations.

I RESULTS OF OPERATIONS FOR THE REPAIR OF NERVE INJURIES —

METHODS OF ESTIMATION

In judging the late results of operations for the repair of peripheral nerve injuries it is necessary to make a clear distinction between two standards of assessment the physiological or neurological and the functional or economic

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The former simply represents the amount of conductivity which has been restored to the nerve as measured by clinical and electrical tests. The latter as the term would indicate, denotes the degree of general utility which the limb or part exhibits apparently as the result of the operation. The two standards do not necessarily run on parallel lines. A good functional result may be seen in the presence of a poor neurological result and on the other hand, with a satisfactory or wellnigh perfect neurological result there may be little improvement in the functional capacity of the limb. The reasons for such discrepancies are not far to seek. It is to be recalled that the effects of a complete lesion of a peripheral nerve may constitute little practical disability in certain individuals. Thus the elimination of the *ulnar nerve* is of paramount importance only to those whose occupation demands the finer hand movements. One of the writers recently had the opportunity of examining a bricklayer under treatment for a wound of the leg who had sustained a complete division of the *ulnar nerve* at the wrist nineteen years before. He stated that his capacity for work had not been lessened by the wasting or loss of sensation in the hand. In lesions of the *median nerve* the anaesthesia of the index finger is a far more serious disability and impairs the capacity of the hand for most types of work.

Again, the loss of conduction and function due to a nerve injury may be overshadowed by the disabling effects of the consecutive or co-existing changes in other tissues. As already stated, the successful repair of the nerve, even if restoration of conduction and function go hand in hand, may then be of no practical value to the patient. Finally, in the absence of mechanical obstacles to the restoration of function, delay may be dependent on psychical causes.

Most of the available records are based on a neurological standard alone. For reasons which are sufficiently obvious, a survey of the economic or industrial capacity of large numbers of war-disabled men would to-day be an impossible task.

The operations which have been practised may be grouped conveniently into three classes. (1) *Operations for the restoration of conduction* (direct and indirect nerve repair), (2) *Operations for the relief of pain and other irritative phenomena*, (3) *Operations designed to restore function in irreparable lesions or in cases of incomplete recovery*.

II RESULTS OF OPERATIONS FOR THE RESTORATION OF CONDUCTION

Under this heading are included *end-to-end suture*, *neurolysis* and the small group of operations best described by the term '*bridging*'.

1 STATISTICS

When an attempt is made to correlate the results recorded by different observers we find that it is safer to avoid the massing together of mere statistics. It is more logical simply to present those broad conclusions which a study of a few typical series of operation results affords us. Before entering upon the latter task, we may quote briefly from some of the larger individual series

of operations which have been published in this country during recent years. When compared with the number of operations actually performed in the various surgical centres, the published statistics are seen to be comparatively scanty. From such centres as the Special Surgical Hospitals at Shepherds Bush and Tooting (London), and the Royal Herbert Hospital, Woolwich—centres in which exceptionally large numbers of operations were conducted by a small group of experienced surgeons—we have no figures. Much of the information, however, which appeared in the *Report of the Peripheral Nerve Committee of the Medical Research Council* issued in 1920 was founded on experience gained in these and other centres where it has not been practicable to follow up the more remote results on a large scale.

Kennedy⁴ (Glasgow) 1919 —

25 operations on various nerves (civil injuries)
End-to-end suture—Complete success in 73 per cent, incomplete success in 26 per cent
Neurolisis—Complete success in 70 per cent, incomplete success in 30 per cent
Complete failures—None

Stopford⁵ (Manchester) 1920 —

271 operations—gunshot injuries
Operations performed by various surgeons Type of operation—end-to-end suture Standard of recovery—neurological
A Upper Limb (median ulnar and musculospiral nerves)
Upper arm—Recovery of varying types in 88 per cent, failures (complete) in 12 per cent
Forearm—Recovery in 76 per cent, failures in 24 per cent
B Lower Limb (sciatic, external, and internal popliteal nerves) Recovery in 85 per cent, failure in 15 per cent

These figures are largely *interim* results

Forrester-Brown⁶ (Edinburgh) 1920 —

475 operations—gunshot injuries
Operations performed by Sir Harold Stiles and the recorder Standard of recovery—neurological

A End-to-end suture—158 operations
(1) All cases

Complete motor recovery 29 per cent
Complete sensory recovery 19 per cent
Complete trophic recovery 21 per cent
Complete recovery of all functions 50 per cent
Incomplete recovery seen in five median nerve sutures and eight musculospiral nerve sutures

(2) Comparison between different nerves
Median nerve—50 per cent complete motor recovery, 28 per cent complete sensory recovery
Ulnar nerve—17 per cent complete motor recovery, 13 per cent complete sensory recovery
Musculospiral nerve—62 per cent complete motor recovery, 33 per cent complete sensory recovery

B Neurolisis—117 operations
43 per cent full motor recovery, 10 per cent full sensory recovery
These figures include both *interim* results and *true end* results

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Platt (Manchester) 1921 —

150 operations—gunshot injuries	
Type of operation—end-to-end suture	Standard of recovery—neuro-logical
Standard of failure—no appearance of conduction after one year or longer	
Musculospiral nerve—35 operations	Recovery in 26, failure in 9 (in 5 sutures of posterior interosseous nerve to main trunk)
Posterior interosseous—1 operation	Failure
Ulnar nerve—47 operations	Recovery in 41, failure in 6
Median nerve—30 operations	Recovery in 27, failure in 3 (all in forearm)
Brachial plexus (infraclavicular)—3 operations	Recovery in 2, failure in 1
Sciatic nerve—25 operations	Recovery in 18, failure in 7
External popliteal nerve—9 operations	Recovery in 1, failure in 5
Interim results in the majority	

Stopford (Manchester) 1923—unpublished figures—gunshot injuries True end-results as illustrated in the type of recovery seen in 157 suture operations In the majority of these cases the period of post-operative observation has extended over three years or more In all the neurological syndrome has apparently reached a final and stationary stage The standard of assessment is neurological, the motor recovery being recorded in terms of voluntary contraction In many of the patients the economic capacity is known, but this information is of little use for statistical purposes

Musculospiral nerve—37 cases
Recoveries in terms of motor function —

Proximal muscles	{ Supinator longus, Extensor carpi radialis longior, Extensor carpi radialis brevior, Extensor carpi ulnaris, Extensor communis digitorum, Extensor minimi digiti, Extensor ossis metacarpi pollicis, Extensor brevis pollicis, Extensor longus pollicis, Extensor indicis	
Distal muscles		
Proximal muscles plus distal muscles (complete)		20
Proximal muscles plus distal muscles (partial)		16
(Extensor brevis pollicis lacking in all)		
Proximal muscles only		1

In two cases of complete recovery the interval between the date of injury and the time of operation was three years and two years respectively In many of the complete recoveries the extensors of the wrist do not function synergically

Ulnar nerve—38 cases (upper arm 19, forearm 19)		
Proximal muscles	{ Flexor carpi ulnaris, Flexor profundus digitorum Ulnar intrinsic of the hand	
Distal muscles		
A Upper arm		
Motor recovery	{ Proximal muscles plus distal muscles (partial) Proximal muscles only	12 7

Ulnar nerve (Upper arm)—continued

Sensory recovery	Restoration of protopathic sensibility in	9
	Protopathic plus partial restoration of epicritic sensibility in	4
	No sensory recovery in	6

B Forearm

Motor recovery	Hypothenar muscles alone	8
	Hypothenar plus one or more of the intrinsic	9
	First dorsal interosseous alone	1

Sensory recovery

Sensory recovery	No motor recovery	1
	Protopathic plus epicritic (partial)	1
	Protopathic alone (complete 3, incomplete 3)	9
	Complete sensory recovery	6
	No sensory recovery	1

Median nerve—43 cases (upper arm 22, forearm 21)

Proximal muscles Pronator radii teres, wrist flexors and long finger flexors

A Upper arm

Motor recovery	Proximal muscles plus distal muscles (partial)	7
	Proximal muscles alone	15
	Protopathic alone	11

Sensory recovery

Sensory recovery	Protopathic plus epicritic (partial)	6
	No sensory recovery	5

B Forearm

Motor recovery	Thenar muscles	9
	No motor recovery	12
	Protopathic alone	9

Sensory recovery

Sensory recovery	Protopathic plus epicritic (partial)	10
	No sensory recovery	2

Sciatic nerve—27 cases

Motor recovery	Internal popliteal plus external popliteal muscles	20
	Internal popliteal alone	7
	Protopathic alone (complete)	2

Sensory recovery

Sensory recovery	Protopathic alone (incomplete)	14
	Protopathic plus epicritic (partial)	6
	No sensory recovery	5

External popliteal nerve—12 cases

Motor recovery	All muscles	6
	One or more muscles	6
	Complete	4

Sensory recovery

Sensory recovery	Protopathic alone	6
	No sensory recovery	2

2 RESULTS OF END TO END SUTURE

The classical distinction between *primary* and *secondary* nerve suture is to some extent purely artificial, for it is often difficult to indicate the exact dividing line between the two procedures. The extreme perfection attained

after many so-called primary sutures in the case of clean-cut divisions has long been appreciated and it is usual to compare such results with the incomplete type of recovery which is the rule in the majority of the secondary sutures. The essential difference from a prognostic point of view, however, is not concerned with the exact chronology of the suture but rather with the contrasted types of lesion and the conditions under which the repair is carried out. The end-to-end sutures in gunshot injuries belong almost exclusively to the secondary class. Under the conditions of emergency war surgery the opportunities for the practice of immediate nerve repair rarely arose, further in the highly-infected wound such attempts were with reason regarded as unjustifiable.

FACTORS WHICH DETERMINE PROGNOSIS

The information and conclusions as to the remote results of suture operations may best be approached by a preliminary consideration of those factors which are known to influence the standards of recovery. From these gross errors in operative technique are excluded.



FIG 315—Cross section of ulnar nerve 21 in above the lesion showing interstitial fibrosis. The dark areas between and around the nerve fibres consist of thickened endoneurium.

Changes in the Nerve-trunk itself—These must be considered in three situations (a) Above the point of suture, (b) About the site of suture, (c) Below the level of suture.

Many failures and partial failures may be caused by changes in the nerve which are beyond the control of the surgeon.

Through the courtesy of Dr. Greenfield, of London, and Dr. Linell, of

Manchester, who have kindly prepared the necessary sections we are able to illustrate these points by means of microphotographs and drawings

a Changes Above the Point of Suture—Of the changes which take place in the nerve proximal to the site of injury and to the suture, the first to be considered is interstitial fibrosis in which the individual nerve-fibres are normal but the endoneurium is thickened

1 *Interstitial fibrosis* is extremely common and may extend far higher in the nerve than was at one time supposed This has been particularly

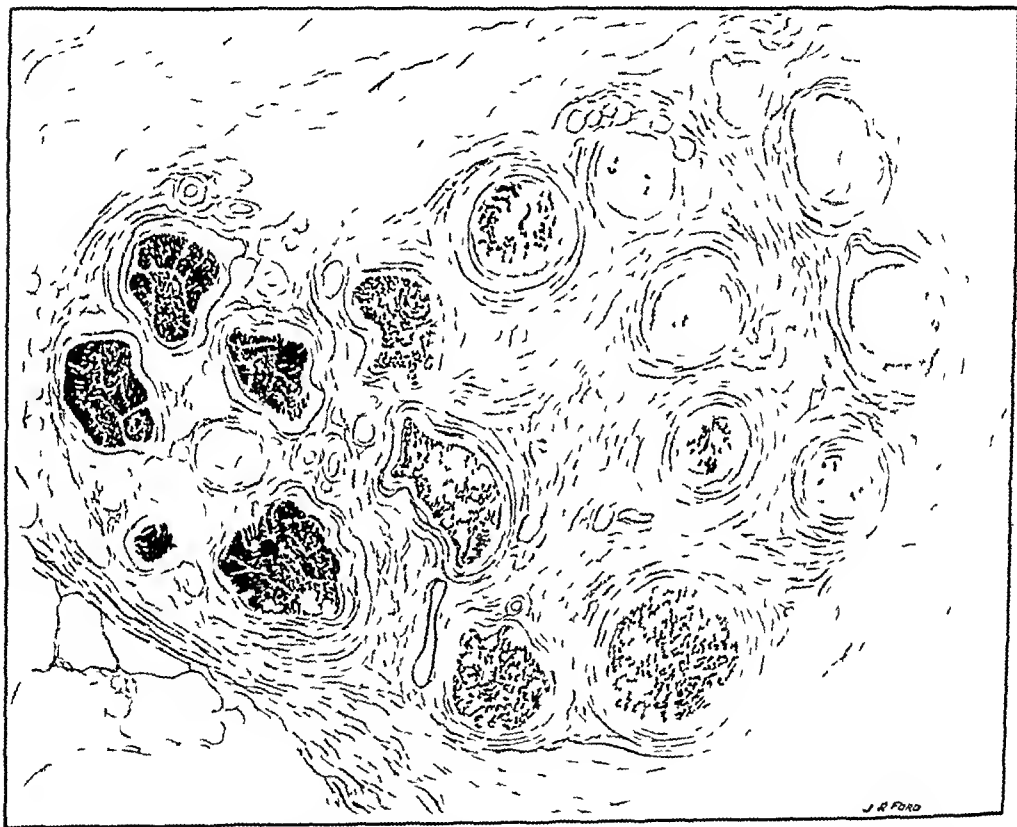


FIG 316—Cross section of posterior tibial nerve 8 in above ankle (/11) stained by Weigert Pal method, showing demyelination on one side (right) of the nerve and partial demyelination of the bundles in the centre of the nerve The bundles on the left show almost normal myelination The bundles on the right are replaced by fibrous tissue and there is a great excess of fibrous tissue between the bundles remaining

marked in those cases complicated by sepsis, as were most war wounds It may be quite impossible for the surgeon to get above the level of this change, as by so doing end-to-end suture would be rendered quite impracticable

Fig 315 illustrates this type of change in an ulnar nerve, 2½ in proximal to the end bulb and shows great thickening of the endoneurium In this connection also the drawings in Figs 316 and 317 must be considered These are from a section taken from a posterior tibial nerve which was removed

from a patient whose foot had been amputated some years after sustaining a gunshot wound. The specimen is taken at least 8 in. above the site of the wound, and was obtained at the time of re-amputation in the middle third of the leg, an operation performed because of pain. The section shows interstitial fibrosis due to an inflammation spreading up one side of the nerve. The nerve bundles at this side are completely demyelinated, and in addition a good many bundles are replaced by fibrous tissue. Towards the middle

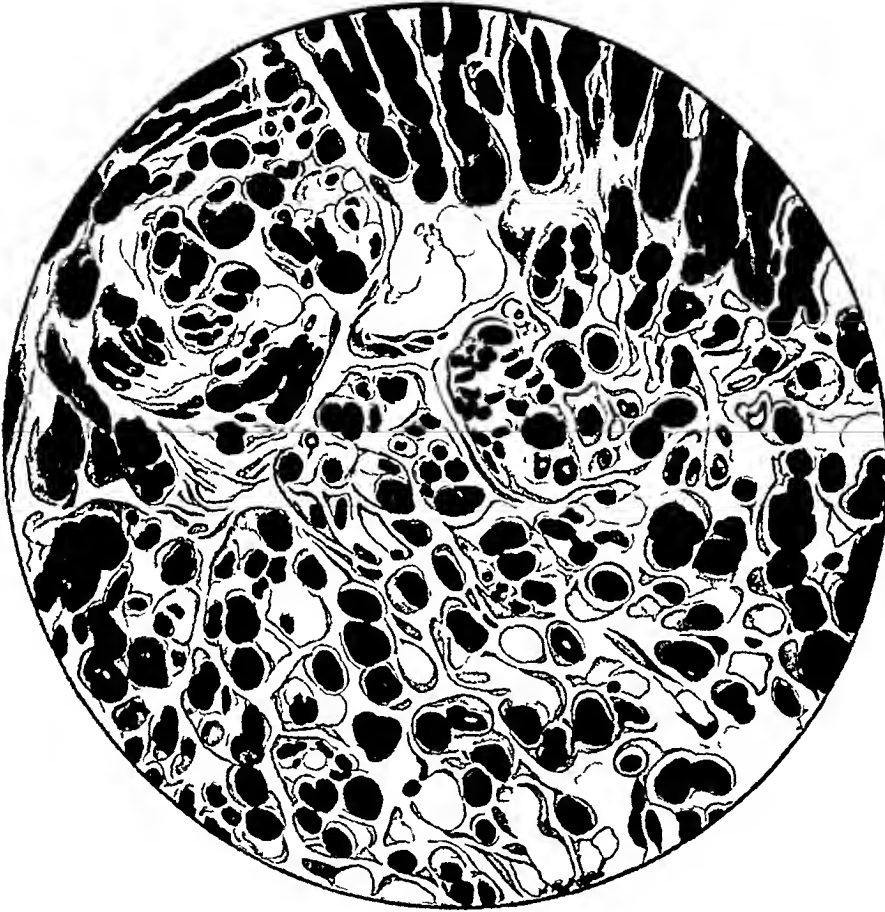


FIG. 317.—Cross section of one of the more healthy bundles in Fig. 316 ($\times 190$), showing intraneural fibrosis and demyelination of some of the fibres.

of the section one sees encroachment of the fibrous tissue on the bundles, whilst those on the opposite side are practically normal and well myelinated. Everywhere there is great thickening of interstitial fibrous tissue. This section illustrates in an extreme degree what is shown to a less extent in a considerable number of nerve lesions associated with pain.

There is another type of change which may occur on the proximal side of the injury, viz., an *ascending toxic neuritis*. This condition is illustrated in Fig. 318, which is taken from the sciatic nerve above the

of the lesion from a patient in whom neurolisis had failed to bring about improvement, and whose leg was ultimately amputated for atrophy and trophic changes. The section shows nerve-fibres separated by œdema and fibrous tissue. Some appear normal with a central axis cylinder, wide myelin sheath, and surrounding nucleated sheath of Schwann. Others have reverted to a protoplasmic condition, i.e., they appear in section as a solid mass of nucleated protoplasm with numerous clear dots which represent fine threads of myelin. The neurofibrils, which are very fine, do not stain. The condition indicates that degeneration has taken place in this nerve above this level, and is followed by a commencing regeneration.

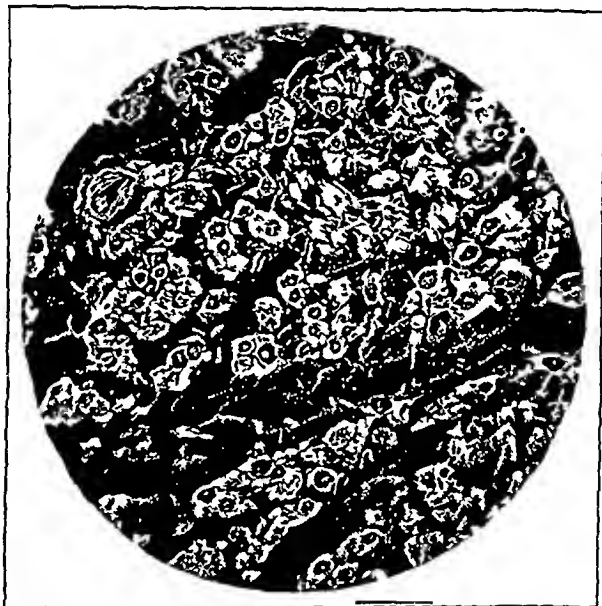


FIG. 318.—Cross section of sciatic nerve above the level of the lesion ($\times 75$), showing separation of nerve fibres by œdema and fibrous tissue. Many normal nerve fibres are seen; others are regenerating and are seen as almost solid protoplasmic rods in which the fine vacuoles represent thin threads of new myelin.

It is apparent from a consideration of these specimens that it is not possible in many instances to get above the site of damage in the central end of a divided nerve when the end bulb is resected and end-to-end suture performed. Moreover, it is not always possible on examining the freshly-cut end at the time of operation to appreciate the true state of affairs, and what changes, if any, are present in this part of the nerve.

b Changes About the Site of Suture.—These include tissue reactions due to the stitch itself and to sepsis, even when mild, and which give rise to none of the ordinary signs of inflammation on clinical examination. The changes are essentially cicatricial, and, when well marked, shrinkage of the suture neuroma may follow some time after its formation.

In this connection a consideration of the drawing taken from a section kindly supplied by Mr. Sargent and Dr. Greenfield will repay investigation.

(Fig 319) The history is as follows. A nerve-grafting operation was performed in 1918 for a large gap in the ulnar. Three years and four months later the graft was exposed, no recovery having taken place. The drawing shows a reaction round a stitch in process of slow absorption. The stitch is of silk material. When seen with a dark-ground illumination there are small portions of stitch material elsewhere in the field. The stitch and the reaction round it represent more than *half* of the transverse section of the nerve.

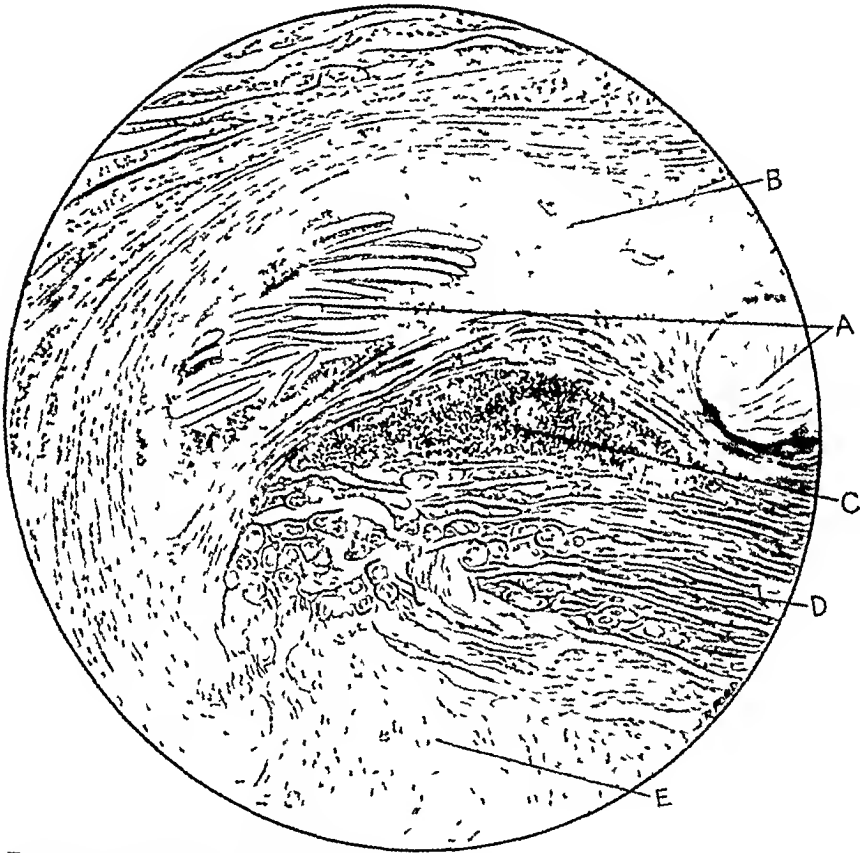


FIG 319.—Longitudinal section of neuroma above junction of proximal end of nerve with graft stained hemalum and van Gieson ($\times 64$). Showing (A) Remains of silk suture material, (B) Mass of phagocytic cells, (C) Area of small round celled infiltration, (D) F, (E) Nerve fibres forming neuroma.

The point to be emphasized here is that there is a good deal of reaction even with the finest possible suture material, and such a reaction must to some extent jeopardize the completeness of recovery.

c Changes Below the Level of Suture—The section of the posterior tibial nerve illustrated in Fig 320 shows that for some unknown reason regeneration may reach a certain stage, and then halt. The microphotograph in this instance is taken from a section of the nerve many inches below the site of repair and two years after end-to-end suture had been performed.

Regeneration of axis cylinders, but with little or no re-formation of myelin, may well be a common end-result in a healed nerve

The Period of Delay between the Original Injury and the Operation (Time Factor)—It was pointed out many years ago by Bowlby that after a certain optimum period—arbitrarily estimated as two years—recovery tended to be less certain and less complete. The truth of these observations has been confirmed by most subsequent writers, and the importance of early repair of a nerve lesion has always been stressed. Our more recent experience tends to bear out this conception. It is, of course, impossible to state dogmatically the exact period of delay beyond which an operation is doomed to complete failure. For practical purposes a three-year limit is a useful working basis. Stopford's extensive clinical statistics on the results of nerve suture seem to show that the optimum period is longer in the case of operations in the proximal part of the limb. It was the considered opinion of the Medical Research Committee on Peripheral Nerve Injuries that, so far as is known, no period is so long as to preclude the possibility of recovery. The harmful effects of long delay depend on the development both of peripheral and central retrogressive changes. The permanent degenerative changes which occur in the muscle bellies after prolonged denervation render these structures less capable of assuming function even though neurotization be established at a later date. But if they have been kept in the best possible condition as regards nutrition by heat, massage and electrical stimulation, the outlook is improved. It has been shown experimentally that if union be prevented after division of a peripheral nerve-trunk a not inconsiderable number of the cells of the anterior cornua and posterior root ganglia disappear completely. It is thus probable that with increasing periods of delay the regenerative process itself is less efficiently initiated and controlled by the spinal centres.



FIG. 320.—Cross section of posterior tibial nerve stained with hemalum and eosin ($\times 75$) several inches below point of suture. There is no interstitial fibrosis. The nerve fibres are seen as solid protoplasmic rods and not, as in the normal case as axis cylinders surrounded by a thick myelin sheath. The protoplasmic rods contain many nuclei of the sheath of Schwann and a few neurofibrils but no myelin.

The Anatomical Situation of the Sutures—Stopford (loc. cit.) has shown that when the proximal and distal parts of the limb are compared sutures in the latter situation show a higher percentage of failures. The reasons for this are complex. It would appear that the regenerative control exercised by the spinal cells is less efficient when the point of section is far distant.

Topographical Confusion in Regeneration—Inadequacies of regeneration due to the shunting of nerve-fibres along inappropriate channels must of necessity be present after every nerve suture. In a clean-cut division of a nerve followed by immediate repair with the avoidance of torsion of either proximal or distal stumps, such errors are minimal and give no clinical evidence of their presence. But in the more extensive lesions in which a generous trimming or resection is necessary, a considerable disturbance of the intra-neural pattern results. The regeneration in such cases may be compared with the process of nerve-crossing in immature. Such regenerative errors are undoubtedly represented in the imperfections of the neurological and functional results which characterize the greater proportion of the suture operations in the case of the more extensive gunshot lesions. The known superiority of the results of suture of the *musculospiral* nerve, as compared with the *median* and *ulnar* nerves illustrates very clearly the part played by this factor. The chances of topographical confusion are especially great also in the case of suture of a nerve of small calibre to a larger trunk, e.g., the posterior interosseous to the musculospiral or the anterior tibial or musculocutaneous to the external popliteal trunk—operations which appear always to be followed by more or less complete failure.

It will be seen from the statistics quoted above that the results of the majority of end-to-end sutures performed for gunshot lesions are imperfect in a neurological sense. The picture is not however such a gloomy one as might appear at first sight, for in the uncomplicated cases the economic standard of recovery is often surprisingly good. There are, moreover, great discrepancies between the results obtained in the case of the different nerves. A study of *true end-results* in a series of operations which have been followed from the beginning shows quite clearly that the mere appearance of signs of recovery in the early stage is no guarantee that such recovery will be progressive.

COMPARISON BETWEEN THE DIFFERENT NERVES

Musculospiral Nerve—All statistics show that this nerve heads the list of recoveries, whether judged from a qualitative or quantitative standpoint. Almost perfect restoration of function has been described in a considerable number of cases, e.g. 20 out of 37 in the end-result series of Stopford. At the same time, a careful examination has shown that, in the majority of these highly successful results, the synergic action of the extensors of the wrist is lacking. It is probable, however, that this deficiency may be remedied by assiduous training after years of occupational use of the hand.

Ulnar Nerve—In this nerve the results have been physiologically imperfect but not necessarily economically bad. Complete restoration of function in the ulnar intrinsic muscles of the hand appears to be unknown, whilst full sensory recovery is also a phenomenon of extreme rarity. The average sensory result involves the restoration of 'protopathic' sensibility alone. There is less difference in the quality of the results obtained in the forearm sutures as compared with the upper arm sutures, than was foreshadowed in some of the *interim* statistics. Many individuals with complete lesions of the ulnar nerve have been known to be capable of engaging in

laborious occupations such as dock-labouring, coal-mining and so forth. But the musician, the artist, and the fine manual worker are seriously handicapped by the incomplete recovery of the muscles of the hypotenar eminence, the interossei, and the adductors of the thumb.

Median Nerve—The results in the case of this nerve have been uniformly disappointing, chiefly owing to the extreme functional disablement consequent on the inadequate recovery of sensibility. This nerve illustrates very beautifully how co-ordination in finer movements is dependent on the complete restoration of the paths for all types of afferent stimuli. A reference to the details of sensory recovery in Stopford's series shows that at the very best there has been little more than the reappearance of full protopathic function, whilst in 16 per cent of the operations no sensory recovery was seen. In more than half in the same series there has been no neurotization of the thenar muscles. The latter disability, however, is usually overshadowed by the effects of the sensory loss, which is manifested most dramatically by the helpless index finger. There is also another type of relative failure seen sometimes after suture of the median nerve, viz., the recurrence and persistence of inveterate pain and hyperæsthesia.

Sciatic Nerve—Here the neurological and economic results have been consistently poor. No case is on record where recovery has been demonstrated in the intrinsic muscles of the foot. The type of sensory restoration has been on the average exceedingly defective, and this has constituted in many patients a source of danger from the tendency to the development of traumatic ulceration in the foot. The earlier and more complete recovery seen in the calf muscles, as compared with the anterior tibial group, has often been instrumental in determining the production of a contracture in patients who have lacked post-operative supervision. As in the case of the median nerve, irritative phenomena are occasionally seen, and add to the serious psychical and physical disablement of the individual.

External Popliteal Nerve—The percentage of complete failures has been high in the case of this nerve, but, on the other hand, very complete types of recovery have been described. In uncomplicated lesions the economic capacity of the individual provided with an efficient walking apparatus is very satisfactory.

Of the results of suture of the less commonly injured nerves the information is too scanty to merit a detailed discussion.

3 RESULTS OF NEUROLYSIS (FREEING OR LIBERATION OF THE NERVE)

It is difficult in many cases to define how far the operations of this class have brought about the recovery which has been seen to follow their application. In many nerve injuries belonging to the category of pure compression lesions, the surgical removal of the compressing agent is rapidly followed by the reappearance of both conductivity and function. This means that the loss of conduction has not been associated with actual degeneration of the axis cylinders. The effect of a neurolysis under these conditions is to restore the mobility of the nerve-trunk in the injured area by eradicating a factor which is the direct cause of a cumulative intraneural trauma dependent on the repeated stretching and friction of the anchored nerve during the natural

movements of the part. Where a compression lesion has been in existence for some considerable time, the restoration of conduction now depends on the occurrence of regeneration alone, and the obstacles to the full attainment of such spontaneous repair are situated in the interior of the nerve-trunk, i.e., the interstitial fibrosis of a traumatic neuritis. Thus, after the elimination of the cause of the trauma at a late stage, there is no certainty of achieving a complete restoration of function. This sequence of events is shown quite clearly in the results of the operative treatment of compression neuritis of the lower trunks of the brachial plexus produced by the various types of supernumerary cervical rib. In 31 of the large series of cases operated on and recorded by Sargent,⁷ muscular atrophy was the predominating symptom. Full recovery of bulk and strength in the affected muscles was seen after operation in 12 only.

The problem in the extensive lesions due to gunshot injuries is somewhat more complicated, for it would appear that extraneural scar tissue usually plays a minor rôle in the production of loss of conductivity. It is therefore difficult to prove that, following the removal of such scar, the later recovery of conduction and function is due to the operation alone. In the graver lesions where the nerve retains its continuity, neurolysis is often legitimately an experimental procedure, to be followed by resection and suture at a later date if signs of recovery do not ensue. It is for these reasons that we do not discuss at great length the results which appear in the statistics already quoted, nor does it seem logical to compare neurolysis and suture results as if they were those of equivalent operations.

Several variants of the operation of simple neurolysis have been practised. The procedures known as 'hairsage' and 'endoneurolysis' have met with little approval in this country. Capsulectomy-neurolysis—i.e., the peeling off of the outer layers of the thickened sheath of a fusiform neuroma (nerve spindle)—has been followed by striking improvement in some cases (Joyce⁸).

4 BRIDGE OPERATIONS

This term is applied to the various methods of filling in an extensive gap in the continuity of a nerve-trunk. Such operations have been practised for many years, and, as a result of much clinical and experimental research, the question of their value has been more or less finally settled. The following methods have been in vogue in the past, and were probably tried by most surgeons during the war period (1914-1918).

a Neuroplasty, i.e. the bridging of a gap by the turning down of a flap from the proximal to the distal nerve stump, or vice versa. This type of operation may be dismissed at once as having been proved both illogical and futile (Stookey⁹).

b Tubulization, in which some form of conducting channel is inserted, such as a tube constructed of fascia, blood-vessels, or some foreign material. These operations have also failed to establish themselves as procedures of any value in peripheral nerve surgery.

c Nerve-grafts—Many of the earlier reported successes in nerve-grafting do not bear scrutiny in the light of modern experience of the many pitfalls

which accompany the interpretation of the clinical signs of recovery. It is generally agreed that down-growing axis cylinders may cross a short gap, utilizing the channels afforded by a graft, whether this be of an autogenous, homogenous, or heterogenous nature. Where a gap is filled in by a graft equal in size to the injured nerve or by multiple small grafts arranged in cable fashion, a sufficient number of axons may in theory be conveyed into the distal nerve-trunk, and thus ensure adequate function. Autogenous cable-grafts, and large homogenous single-trunk grafts, have been used extensively in recent years by the American and French surgeons, but have rarely been employed in this country. A considerable literature has now accumulated dealing with the general failure of such operations. It is fair to state, however, that evidences of regeneration may be seen when a *short* gap is bridged by a large graft or number of grafts which reproduce the full calibre of the injured nerve-trunk.

The writers have had the opportunity of examining a considerable number of patients who have been subjected to nerve-grafting operations, including those examined and reported on by the Medical Research Council and referred to in the Addendum of the Report published by that body. The majority of these operations were complete failures, but in a few, evidence of partial recovery was established. In one patient a gap of $3\frac{1}{2}$ in. in the ulnar nerve in the arm had been filled in by a portion of the internal cutaneous removed from the same limb. Three years and three months later there was recovery of voluntary power and faradic excitability in the flexor carpi ulnaris, flexor profundus digitorum, and the abductor minimi digiti. There was little recovery of sensation, as complete anaesthesia to light touch persisted, whilst appreciation of pinprick over the little finger was imperfect. A second patient who showed evidence of some recovery was a man with a musculospiral injury which had been grafted with alcoholized human nerve. Two years and four months from the date of the operation there was recovery of voluntary power in the supinator longus and the wrist extensors. There was no recovery in the thumb extensors, nor could the fingers be voluntarily extended. These two patients represented the best results of nerve-grafting we have seen.

In irreparable injuries of certain nerves, where no alternative operation for the restoration of function is available, a graft operation may thus be legitimately practised. But the cases calling for this treatment are few, and become still fewer with increasing experience. The surgeon must not lessen in any way his efforts to obtain end-to-end suture, even by a two stage operation, no matter how exhausting and tedious the procedure.

The attitude of British surgeons towards the value of nerve-grafts continues to be one of scepticism.

d Nerve-crossing — Lateral Implantation (Nerve Anastomosis)— Various types of nerve-crossing have been tested, both in experimental work and in the actual operative repair of nerve injuries. In the latter case the distal stump of the injured nerve must be brought into contact with divided axis cylinders in a neighbouring nerve. There are certain obvious *a priori* anatomical and physiological objections to this method of indirect nerve repair. When efficiently performed, the operation involves considerable

damage to the reinforcing nerve, and for reasons concerned with topography an anastomosis between important mixed nerves is bound to be a haphazard proceeding. The successful cases of nerve-crossing recorded in the literature in the past appear to be limited to operations for injuries of the supraclavicular trunks of the brachial plexus and of the facial nerve. In seven examples of implantation of the distal end of the ulnar (injured nerve) into the median nerve examined by Stopford and one of the writers (H P), there were failure of regeneration and signs of interference with the conduction in the median nerve in all.

It is only fair to record that Joyee showed two patients on whom he had performed a double lateral implantation to the Medical Research Committee, which reported as follows —

“In the case of an *ulnar nerve* which had been divided in the middle of the forearm an incision had been made across one-third of the median nerve and the proximal cut end of the ulnar had been sutured to the distal face of the section. A similar incision across one-third of the median nerve had been made $3\frac{1}{2}$ inches lower down, and the distal end of the divided ulnar sutured to its proximal face. Examined two years later the condition was as follows. Doubtful voluntary contraction was present in the abductor minimi digiti, but both this muscle and the abductor indicis responded to faradic stimulation. Pin-pricks were appreciated within the whole ulnar area except over the terminal phalanx and the ulnar border of the middle phalanx of the little finger. Deep sensibility was present in the whole ulnar distribution. No defect could be demonstrated in the functions of the median nerve.

“In the case of a divided *median nerve*, the proximal and distal segments had been implanted laterally into the sheath of the ulnar nerve, every effort having been made not to injure any fibres of the ulnar. Examined thirty-four months after this operation, the condition was as follows. The radial border of the metacarpal bone of the thumb could be distinctly seen and felt, but the thenar eminence as a whole was very little wasted. The abductor brevis pollicis reacted briskly to a strong faradic current, although it was doubtful whether the patient could contract the muscle voluntarily. The action of the opponens, whether voluntary or to faradic stimulation, could not be definitely decided. The patient was able to appreciate pin-pricks over almost the whole of the terminal phalanges of the index and middle fingers. Sensibility to cotton-wool was wholly absent. Deep sensibility was perfect, but the lesion of the nerve was too low for it to have been originally affected.”

In this country one or two surgeons still practise and champion nerve-crossing operations, but, as far as we know, they are not subscribed to by the majority and are generally condemned for the reasons given above.

III RESULTS OF OPERATIONS FOR THE RELIEF OF PAIN AND OTHER IRRITATIVE PHENOMENA

In the main, the gunshot injuries of peripheral nerves have given rise to but little in the way of pain although milder irritation symptoms have been seen not infrequently. In a few cases pain has been severe.

Clinically, it is of the greatest importance to differentiate between the pain of true *causalgia* and the pain evoked by stimulating a recovering nerve area. At a certain stage in recovery any stimulation in the area of sensory supply which is felt at all is appreciated as pain. This is a normal phenomenon which exists in most recovering nerves for a short time, but in some rare cases has been known to persist for long periods. This type of pain must not be mistaken for *causalgia*, it is not spontaneous, has no emotional causation, but is the direct result of stimulating an area of skin which is no longer anaesthetic but which can appreciate pinprick and pressure, but cannot appreciate the fine degrees of sensation, e.g., light touch (epileptic sensation).

Illustrative case—Following a lesion of the internal popliteal in a patient (Capt W.), recovery reached this stage and remained stationary for fifteen months. The nerve showed no sign of further regeneration, and the state of the patient was intolerable. Any pressure on the sole of the foot was painful, and he was unable to walk or even stand with full weight on the limb. This limb was eventually amputated below the knee. The histological changes in the posterior tibial nerve are illustrated in Fig 320 and have already been discussed. The association of imperfect myelination with the persistence of signs of irritation is suggestive.

In *causalgia* (first described by Paget and named by Wen Mitchell) there is severe pain, spontaneous in onset and of a burning character. It is intense and persistent in type, and subject to exacerbations. It is brought on by causes other than physical, the paroxysms may be induced by the banging of a door, sudden movement, or indeed by any factor which plays on the emotions. The patient may walk about, or sit huddled in a corner, the limb wrapped in a wet cloth, the picture of misery and mental anguish. He avoids any and every form of stimulation, and shuns his fellows. The hunted, haggard expression of a patient with true *causalgia* when once seen will not be forgotten. In many cases the loss of conduction is slight, and is completely overshadowed by the sensory manifestations.

In the minor grades of the irritation syndrome, non-operative measures alone have often brought about complete relief, and in a certain proportion of cases of *causalgia* proper, the timely exhibition of drugs, combined with psychotherapeutic treatment, has rendered operative interference unnecessary. In the majority of cases of the latter condition, however, it was found advisable to explore the injured nerve.

The following operative procedures were commonly practised in this country—

Neurolysis—Simple freeing of the nerve is generally quite effective in relieving the milder forms of irritation but was found to be of little value in true *causalgia*.

Resection and Suture—Gratifying results have been seen after this operation which is to be regarded as one of the two methods of choice.

Intranerval Injection of Alcohol—In practised hands this procedure has given results equivalent to those seen in resection and suture.

The operation of *posterior root section* has been carried out in a few grave cases where resection and suture failed, but it is agreed by most

authorities that this procedure should be advised under exceptional circumstances only

The operation of *Leinche*¹⁰ (peri-arterial sympathectomy) has gained few adherents in this country and no figures are available as to its value in the hands of British surgeons

There are few published statistics dealing with the results of the operative treatment of causalgia, so that the following series of one of the writers (H P) may be quoted

Median Nerve—14 operations in 11 patients

1 Resection and suture—11 (two on the same nerve)

Success complete relief of pain—9

Failure incomplete relief of pain—2 (same patient), cause of failure, interstitial fibrosis above level of resection

2 Neurolysis—2

Success nil Re exploration in both—resection and suture

3 Injection of quinine and urea—1

Incomplete relief Gradual subsidence of irritation after one year

Sciatic Nerve—11 operations

1 Total resection and suture—9

Success immediate—9

Failure immediate—none, remote result—return of irritation symptoms during regeneration—2

2 Segmental suture of internal popliteal half—1

Immediate success Severe irritation during regeneration

3 Neurolysis—internal popliteal—1

Relief of pain

IV RESULTS OF OPERATIONS DESIGNED TO RESTORE FUNCTION IN IRREPARABLE LESIONS OR IN CASES OF INCOMPLETE RECOVERY

The problems afforded by the irreparable nerve lesions, and the cases of incomplete recovery after nerve suture, differ in degree but not in type. The operations applicable under such circumstances consist in (1) Attempts to restore motor function or to achieve a reasonable degree of compensation and (2) As a last resort the elimination of a useless, dangerous, or painful limb. Similar restorative procedures have long been practised for the residual paralyses of anterior poliomyelitis. In the case of incomplete recovery after suture it is important from an economic standpoint, to decide whether the condition is to be regarded as final and all treatment discontinued, or whether it is worth while performing some alternative operation. Months and years may be wasted in a vain attempt to improve function by massage, electricity and allied physical treatment in patients in whom recovery has reached its final stage. Many patients who have had a divided *sciatic nerve* and in whom little or no recovery of nerve conduction has been regained, particularly on the sensory side have a better industrial outlook when the limb is amputated. A great number of such amputations have been performed, and many are still to be performed with definite benefit to the war-pensioner. The thus wasted atrophic foot particularly liable to pressure sores—often incorrectly called trophic ulcers—is an encumbrance, and in such cases a below-knee amputation and a well-fitting artificial limb materially lessen the final disability.

Amputation is sometimes called for to remove the stiff, contracted fingers following incomplete recovery in a lesion of the *ulnar nerve* for in these cases the operation of arthroplasty on the interphalangeal joints has been disappointing in its results

Failures or partial failures after operations on the *musculospiral nerve* have been very successfully treated by tendon transplantation. The exact technique and details of this procedure will vary, but in the main the operation which has been most efficient is as follows—(it was originally devised by Sir Robert Jones) —

Transplantation of the

Pronator radii teres into the extensores carpi radiales longus and brevis,

Flexor carpi ulnaris into the extensor communis digitorum and extensor longus pollicis

Flexor carpi radialis into the extensor ossis metacarpi pollicis and extensor brevis pollicis

The results of this operative procedure are striking—a useful and strong hand is obtained, a hand capable of being utilized for most ordinary occupations

Other tendon transplantations are occasionally of service to assist function, e.g., after lesions of the *median nerve* to restore some power in opposing the thumb, but these are not commonly practised

Where there is no recovery after lesions of the *external popliteal nerve*, attempts have been made to remedy the resulting foot-drop by tenodesis, i.e., the converting of the paralysed dorsiflexors of the foot into ligaments by attaching them to the tibia. These newly-formed ligaments tend to stretch, and for this reason the operation is not often employed. It has been found that a light side-iron, with a toe-elevating spring attached, yields a better functional result in the majority of patients

The residual disability following a fairly successful nerve suture is often capable of improvement by simple operative means if the patient is carefully examined and his exact disablement analysed. As examples may be quoted the short tendo Achillis, or fixed flexion deformity of the interphalangeal joint of the great toe following a sciatic injury. Such disabilities are not infrequently overlooked

SUMMARY

1 The results of *end-to-end suture*

The results of end-to-end suture in the case of gunshot lesions are for the most part imperfect both from a neurological and economic standpoint. In an average large series of consecutive operations, complete failures will be found in about 20 per cent

a The *musculospiral nerve* heads the list of recoveries and may be expected to show practically complete restoration of function in at least 50 per cent of the successful cases

b The *ulnar* and *median* nerves give disappointing results on the whole. In the former complete recovery in the intrinsic muscles of the hand is so rare as to be almost unknown, in the cases showing recovery neurotization

of the hypothenar muscles alone is fairly constant. The economic results, however, in this nerve are often good, except in individuals whose occupation demands the finer co-ordinated movements of the fingers. In the *median* the sensory recovery is always inadequate, and this factor is the cause of the great depreciation in the function of the hand. In sutures of the median in the forearm, complete failure of recovery in the thenar muscles is frequently seen.

c. The results of *sciatic nerve* sutures are poor, and a considerable number of such limbs come ultimately to amputation.

2. The outstanding causes of failure or imperfections—apart from *delay*, or gross *errors* in operative technique—are (a) Changes in the nerve above the line of suture—either interstitial fibrosis or an ascending neuritis—due in either case to wound infection, (b) Topographical confusion in regeneration.

3. The operations of *indirect nerve repair* (with the possible exception of nerve-grafting) have proved ineffective, and should be eliminated from the repertoire of peripheral nerve surgery. Investigations of the results of a small number of nerve-grafting operations in this country suggest that these procedures are of limited value.

4. In the nerve lesions associated with profound mutilation (causalgia), resection and suture, or the intraneural injection of 70 per cent alcohol, will rarely fail to bring about immediate and complete relief of the pain, but at the cost of the signs and symptoms associated with complete division of that nerve.

In conclusion, we would wish to make it clear that although a fair and critical survey of the nerve injuries of the war must leave us pessimistically inclined, yet there is a brighter side to the picture. War injuries are complicated by sepsis, but the prognosis for the nerve injuries of civil life must be vastly better, and the experience gained in nerve surgery on the scale which has been possible will help to crystallize our ideas for the benefit of the patient, and for an improvement in surgical teaching.

The writers are particularly indebted to Professor J. S. B. Stopford for placing at their disposal statistics hitherto unpublished, and to Dr. J. G. Greenfield, who, in addition to the preparation of histological specimens, has given much helpful advice and criticism.

A CRITICAL SUMMARY OF THE DISCUSSION UPON THIS SUBJECT AT A MEETING OF THE SIXTH CONGRESS OF THE INTERNATIONAL SOCIETY OF SURGERY, HELD IN LONDON ON JULY 19, 1923

In the summary which follows certain comments or criticisms are interposed which are meant to interpret, in the judgement of the writers, the views of those British surgeons who have had special experience in this field of surgery. As in the case of the British report the discussion was limited almost entirely to a consideration of the peripheral nerve injuries peculiar to warfare.

Dr Henriksen, of Skien, in presenting the opening report, stated that after a nerve had been divided cleanly it showed a tendency to heal spontaneously. Sensation in the anæsthetic area returned almost at once, and motor power reappeared in about two months. The results were the same whether the nerve was simply cut by a sharp instrument or whether suture was performed after a preliminary resection. He thus considered that primary suture was followed by immediate healing and restoration of function, and further that a cleanly performed secondary suture yielded an equivalent result and in the same short space of time. The majority of those taking part in the debate were not in agreement with Henriksen. It is almost universally conceded that errors of interpretation explain the abnormally early clinical signs of recovery.

Dr Henriksen then dealt with certain factors which prevented healing (1) The interposition of fat, or of scar tissue resulting from sepsis, (2) The degree and extent of the local damage. He regarded a crush or severe bruising of the nerve as a serious obstacle to the occurrence of spontaneous regeneration. The injury sustained by the nuclei of the sheath of Schwann might prevent recovery, for if nuclei were destroyed on a large scale, no new nerve fibres were formed and the nerve atrophied. It may be stated here that Henriksen is a strong adherent of the peripheral theory of regeneration, which he has supported by a good deal of careful experimental work.

Dr Gosset, of Paris, presented a full report of his own work, and quoted also that of other leading French surgeons. Tables showing his own personal results and also those obtained by other observers are given on the opposite page.

He divided the substance of his contribution into three parts —

1 INJURIES OF NERVES REQUIRING OPERATION —

a All cases of compression which tend to progress and lead to serious interruption or show evidence of irritation. He considered that liberation of the nerve—neurolysis—should be undertaken in all these cases without delay. The operation was of the nature of an exploration, and could harm neither the patient nor the nerve when carefully performed.

b All cases of complete interruption. Gosset stressed the importance of an exact diagnosis, as far as this is possible. He emphasized the necessity of repeated examinations by skilled neurologists. Nerves showing no signs of regeneration, or in which regeneration had reached a particular stage and then ceased required operation.

c All cases of causalgia or serious neuritis usually required operation but for these difficult conditions no exact rules could be laid down, such cases must always be considered on their merits.

2 THE TIME OF OPERATION — Early operation was advisable as a general routine —

a In war surgery the condition of the main nerves should always be investigated and noted during the preliminary surgical cleaning of the wound. Any severed nerve should be sutured at once, in order to prevent deviation or displacement, the interposition and growth of fibrous tissue between the cut ends, and also in order to permit of rapid regeneration. If the nerve

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is found to be bruised but not divided, it should be preserved and kept under careful observation

b If a period of time has elapsed before the patient comes under observation, and a nerve lesion is diagnosed, operation should be undertaken at the earliest possible moment, but as asepsis is essential, it is imperative to wait until all signs of inflammation have disappeared for some weeks

DR GOSSET'S TABLE TO SHOW THE PERCENTAGE OF COMPLETE SUCCESSES OR MARKED IMPROVEMENT

NERVE	NEUROLYSIS	SUTURE
Musculospiral	95 per cent	45 to 55 per cent
Median	47 " "	44 " "
Ulnar	43 " "	17 " "
Sciatic—trunk, 1917	55 " "	35 " "
" " 1920	—	40 " "
Sciatic—external popliteal	66 " "	50 " "
Sciatic—internal popliteal	—	40 to 50 " "

TABLE TO SHOW THE COMPARATIVE PERCENTAGE RESULTS IN THE PRACTICE OF VARIOUS SURGEONS

SURGEONS	NO OF CASES & SUTURED	SUCCESS OR MARKED IMPROVEMENT	IMPROVEMENT	FAILURE
		Per cent	Per cent	Per cent
Ceston	23	—	74	26
Dane	98	50	—	—
Delagunière	236	—	88	—
Donati	—	46	34	20
Fere	20	55	15	25
Forgues and Jumentie	22	14	45	41
Gosset and Charrier, 1917	140	45	—	—
Gosset and Charrier, 1920	54	50	25	25
Joyce	36	37	23	40
Platt	150	—	79	21
Putzu	40	—	37	—
Wyre Babcock	170	—	25	—

3 THE TYPE OF OPERATION ADVISABLE —

a Neurolysis—simple liberation of the nerve, and its reposition in a new bed between healthy muscles—is applicable where the syndromes of compression or irritation are present. Foreign bodies embedded in the nerve should be removed. The removal of fibrous tissue from between the nerve bundles should only be practised when this can be done without damaging the healthy part of the nerve.

b Resection and suture of the sheath, without traction should be undertaken for complete division, or when the nerve fails to show signs of regeneration after several examinations. If end-to-end suture is not possible a graft should be inserted. Gosset emphasized the importance of physical treatment

in both the pre- and post-operative stages, in order to prevent ankyloses and adhesions, and to keep the limb in the best possible condition. He pointed out that regeneration might go on from eighteen months to several years, and that treatment should be persevered with. He drew a sharp distinction between the end results of immediate and delayed suture. Immediate suture, whether in civil or military surgery, should normally be completely successful. When a period of from one month to two years has elapsed between the injury and the suture, operation should yield 40 to 50 per cent of good functional results. After an interval of two years the proportion of successes was less, but suture should still be attempted. He considered that prolonged observation was essential, and that nerve surgery carefully and systematically practised by "specialists who are equipped for that purpose" yielded satisfactory results.

Dr Gosset's report represented a most comprehensive survey of the whole subject. His conclusions in the main were similar to our own, excepting in so far as he did not mention the two-stage operation, and that he favoured nerve-grafting where end-to-end suture was not possible.

Professor C. H. Frazier, of Philadelphia, stated that the American casualties in the great war exceeded 200,000, and that of these about 3,500 had peripheral nerve injuries. With few exceptions the operations on which his report was based were performed by specially trained surgeons at one or other of twelve centres in the United States. As regards the time when operation should be undertaken, it was the general practice in America to defer operation until three months after the wound had healed. Experience had shown that signs of spontaneous regeneration might commence as late as six months after the time of the injury, and in rare cases at an even later date. He referred to a musculospiral nerve injury which showed the first sign of regeneration after a delay of twenty-one months. He knew of cases in which successful suture had been performed after a delay of two years between the time of injury and the operation. He considered that if there was no evidence of regeneration six months after the injury, or regeneration had failed to progress, or there was evidence of neuritis, operation was called for.

The damaged nerve should be resected sufficiently to expose healthy bundles above the site of injury, and end-to-end suture be performed. Six or eight silk sutures through the sheath were necessary and a stay stitch (catgut) was sometimes used when the suture was of necessity under any tension. With increasing experience, the actual resection tended to become more extensive. Partial resection was a delicate operation and one which was seldom performed. Every effort was made by positioning the limb by transposition of the nerve if practicable, and by extensive freeing, to get the ends into apposition, but when the gap was too great to allow of approximation of the freshened ends Frazier advocated the two-stage operation in preference to bridging the gap by means of a graft. In his experience graft operations, with only a very few exceptions, had been uniformly unsuccessful.

As regards true end-results the same difficulty had been experienced as in Great Britain. The patients had become widely scattered. He presented the following table based on 496 cases operated upon and made up as follows: end-to-end suture 350, neurolysis 132, grafts 14.

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TABLE TO SHOW THE END RESULTS OF NERVE INJURIES, BASED UPON
496 CASES OPERATED UPON

NERVE	RESULT		
	Good	Medioere	Negative
	Per cent	Per cent	Per cent
Brachial plexus	33	37	29
Musculospiral	23	30	46
Median	58	28	14
Ulnar	12	55	31
Sciatic	25	41	33
External popliteal	31	52	16
Internal popliteal	46	46	8

Recovery after suture was rarely perfect. It was difficult to account for the high percentage of failures in certain nerves, such as the external popliteal, and the question of the bearing of the intraneural plexuses upon this point had elicited divergent views in America. Frazier considered that the chances of success in the case of the median ulnar, musculospiral and sciatic nerves were sufficiently good to warrant re-exploration and suture if failure of regeneration persisted. Frazier's conclusions were thus very similar to those arrived at by British surgeons.

The paper prepared on the work of the Italian surgeons by the late Dr Veiga, of Pavia, was communicated by Dr Chiasseroni of Rome. He called attention to the experimental work on peripheral nerve injuries which had been accomplished at the University of Pavia under the direction of Professor Golgi. He stated that the operation of choice was end-to-end suture, and that the results obtained by this operation and by neurolysis in suitable cases were far superior to those of grafting or any form of nerve-bridging.

Dr Veiga had prepared a summary of 82 cases observed for a period of over a year. The results showed Recovery 52.4 per cent, improved 37.8 per cent, failure 9.7 per cent. By recovery he did not necessarily mean a perfect neurological or functional result. Amongst his series were included cases in which there was some weakness and inability to stand fatigue so that the limb became very easily tired. He regarded perfect recovery as exceedingly rare. He considered that the longer these patients were followed up the more improvement was shown and that improvement was often largely a question of time. In a small series of cases carefully watched over a period of six and a half years improvement was noted in all. He made no mention of the two-stage operation for suture. He considered that grafting should not be condemned as it might give good results but should only be resorted to after failure of the more standardized procedures.

In the discussion which followed the papers by the reporters of the various countries Dr Chiasseroni dealt with the question of nerve-grafting at greater length and claimed to have had a successful result from the implantation of an alcoholized graft in the case of a divided median nerve in the forearm. In this case the sensory recovery was good and the motor recovery fair. He

showed a series of lantern slides illustrating the results of nerve-grafting operations in experimental work on dogs. These experiments showed that some months after the operation the nerve appeared almost normal on naked-eye examination, and that on histological investigation nerve-fibres could be followed through the graft into the distal trunk. He considered that the almost universal failure of nerve-grafts in man was largely a question of faulty technique. He stated that a graft of approximately the same thickness as the injured nerve was needed, and should be placed in position either as a single trunk or as a cable graft—i.e., a series of smaller grafts placed parallel to each other and so filling up the gap. It may be remarked that cable grafts have been employed both in this country and in America, but with scanty success.

Dr. Leriche, of Lyons, continued the discussion and dealt with four main points: (1) The treatment of causalgia, (2) The results of Nageotte's dead heterogenous grafts, (3) The treatment of trophic troubles, (4) The possibility of improving the results of nerve operations.

He considered causalgia a vasomotor syndrome, and referred to his earlier work on the subject (1916) and to that of Pierre Marie and Meige. Causalgia did not necessarily clear up spontaneously, as had been considered usual by some authorities; he had examined two cases during 1923, one of whom was wounded in 1914 and the other in 1915. In his experience the condition could follow minor accidents, such as a crushed finger, which did not involve main vessels or large nerve-trunks. When it followed a nerve injury it was nearly always a median or sciatic lesion, and in either case the nerve possessed its own artery.

The condition was divisible into two phases—a peripheral and a central.

1. In the early or peripheral phase the operation of peri-arterial sympathectomy was often successful. In 9 cases he had obtained 5 very good results—the patients returning to a normal working life—2 partial successes, and 2 failures. The failures were due to the disease having reached its second or central phase, or to the operation having been carried out at too low a level. It was necessary to perform sympathectomy in the upper arm for lesions limited to the hand, and to operate in the axilla for pain reaching to the elbow. Gosset had recalled Platon's statistics, 9 improvements out of 12 cases, and Turbin, of Moscow, had reported 8 cases, all of which were successful.

2. For the second or central stage, posterior root section or division of the pain tract in the cord itself was needed.

Dr. Leriche emphasized the fact that he firmly believed that resection and end-to-end suture, or blocking the nerve by alcohol injection, should not be resorted to unless peri-arterial sympathectomy had been tried and had failed. He referred to the fact that amputation in these patients was always useless, and failed to cure the pain.

He reported his results in 20 cases of heterogenous nerve-grafts, based on Nageotte's experimental work. 3 cases of early operation during the war under ideal conditions, and 17 cases of late operation after old war wounds. The results were unsatisfactory on the whole. One early case yielded a fairly

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good result one was not traced and one failed after showing only evidence of improvement. In the later operation series of 7 patients examined two to three years later only 1 showed improvement. He referred to some of the possible causes of failure and related how in one patient a histological examination of the graft was made possible. No new axons had been able to reach the graft as a fibrous tissue block occurred about the proximal end at the junction of graft and nerve. He considered that autogenous grafts were preferable and that heterogeneous grafts should no longer be employed.

Dr Leriche next discussed the treatment of trophic disturbances and strongly urged that the operation of periautal sympathectomy should be given an extended trial. In his hands the results had been favourable whether the operation was performed alone or combined with a resection of the neuroma and a graft. The operation failed in very severe and advanced cases. For these amputation was needed and he discussed the question of the level at which such amputations should be carried out. As the most of the surgery of peripheral nerve injuries could be improved. As the most important factors, he mentioned early intervention and the greatest possible attention to the nutrition of the paralysed or affected limb. Once again he suggested the operation of periautal stripping as an adjunct to prevent or diminish contractures and tissue change. "Operation on the sympathetic is in every way a valuable method to be studied and used as an additional measure in operations on peripheral nerves."

Mr Archibald Young, of Glasgow, said that his remarks were primarily based on a series of 125 operations on nerves during the period 1911 to 1919 but that he had been interested in this subject since his earliest communication, made at the time of the South African War. Of these 125 operations 59 were neurotomy (resection and suture) and 66 neurolyses. Young discussed the technique of suture and expressed the view that the finest catgut was the best material. He regarded the use of non-absorbable material such as silk as unjustifiable. He discussed the value of protecting the nerve junction after suture by a sheath, and for this purpose had carefully recorded and analysed the results in his own series of operations. In his opinion the use of an efficient sheath improved the result and he considered a sheath of fatty tissue obtained from the operation area or excised through a separate incision from the chest wall, the most satisfactory for this purpose.

Young contrasted the results in war surgery and in civil practice, and he thought that the disturbing effects of persistent and continuous searing, rather than the complication of sepsis in the wound at or after suture, accounted for the poor results in the war cases. He gave his own results of autogenous grafting operations in 8 cases, viz median, 3 cases, partial recovery in 2, ulnar, 2 cases, result unknown in 1 and uncertain in the other, musculospiral, 3 cases, recovery in 2 and failure in 1.

SUMMARY OF THE DISCUSSION

It will be seen that, with a few exceptions, the conclusions formulated by the American and Continental surgeons differ very little from those of the British surgeons which are embodied in the preceding report of the writers. The experience of the American surgeons, indeed, as presented by Frazier, forms an exact parallel to our own. The reporters were unanimous on certain points, such as the need for the segregation of these patients under the care of surgeons experienced in this branch of surgery and under conditions where prolonged and careful post-operative treatment can be carried out. In this connection, those British surgeons who took part on a large scale in the peripheral nerve surgery of the war period are not unmindful of the great debt they owe to Sir Robert Jones for the organization he created, and for his personal leadership.

The advantages of early operation were emphasized by all, and there was general agreement that resection and end-to-end suture was the operation of choice in every case of nerve injury where the nerve was divided or badly damaged.

If direct end-to-end suture was not possible, the American and British surgeons supported the two-stage operation, whilst the Continental surgeons utilized one or other of the various methods of grafting to bridge the gap. They preferred if possible the autogenous graft, but placed more reliance on the results of this method than we believe is warranted by the statistics quoted.

Certain familiar points in technique were raised during the discussion, e.g., the wrapping of fat or fascia round the suture line, but on the whole the opinion was definitely against the retention of this procedure. It was generally felt that if the nerve bed was not satisfactory, transposition into a new intra-muscular bed was all that was needed.

A stimulating atmosphere was introduced into the discussion by the vivid contribution of Leriche in which he strongly urged the more general adoption of his operation of peri-arterial sympathectomy. He insisted on its value in dealing with causalgia, trophic changes, and in fact in all cases with signs of nerve irritation. The operation has not been extensively practised in this country, and, as far as we can judge from the few results known, it has not been highly successful. Whether or not it will take the prominent place in this branch of surgery that Leriche and his followers believe it should occupy, time alone can show. The inherent objection to the rationale of the operation at the present time is its lack of sound anatomical basis. For whilst much remains to be worked out concerning the distribution of the sympathetic fibres in the limbs, it is quite certain that the mass of these fibres do not form a continuous chain localized to the sheath of the main artery over the whole of its course.

On the whole, it was felt that the results of nerve suture in the case of war wounds were disappointing. In many instances, however, it has been encouraging to find that they tended to improve after long intervals. Infection was the outstanding factor in the production of failures, and for this reason the prognosis in the nerve injuries occurring in civil life must always be markedly better.

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TEMPORARY EXTRA-ABDOMINAL INTESTINAL ANASTOMOSIS THROUGH A TUBE

By D P D WILKIE, EDINBURGH

THE question of effecting a short-circuit of an obstruction of the intestine by means of a tube leading from the distended bowel above to the empty intestine below is one which, so far as I can gather, has received little attention from surgeons. The possibility of such an arrangement being able to function was unknown to me until, almost by accident, it was tried with complete and striking success. The indications for the use of such a device will probably be limited to cases such as the one described below where obstruction supervenes in a case of diffuse or generalized peritonitis and where the condition of the patient precludes the performance of any major abdominal operation for its relief. The following particulars are from the notes of the case in which this procedure was tried successfully.

Case — M^r C, age 38. On May 28, 1922, the patient felt out of sorts in the morning, but was able to go to a cricket match in the afternoon. On the following day he had several severe spasms of abdominal pain and felt sick, but did not vomit. When seen by his doctor on the evening of May 29 he was suffering from colicky abdominal pain. His pulse and temperature were normal, and with the diagnosis of a chill he was given a dose of castor oil. Thereafter the colicky pain became more acute, and at 10 a.m. the following day his doctor was again called and found him looking very ill. There was now very marked tenderness and rigidity of the lower abdomen, acute appendicitis was diagnosed and he was removed to a nursing home for operation.

PREVIOUS HISTORY — When a youth he had an illness suggestive of appendicitis and had noted occasional pains in the lower abdomen at intervals since then. He also suffered from aortic stenosis and incompetence, and had a very much hypertrophied heart.

OPERATION, 3.0 a.m. May 30 — Guidon incision in right iliac region. Seropurulent exudate with faeculent smell escaped. An appendix, which was partly gangrenous and had perforated near its base, where a concretion was tightly impacted in a stenosed area, was removed. The appendix contained dark fluid faecal matter, some of which had escaped through the perforation. A rubber drain was left in leading to the pelvis.

The patient took the anæsthetic (ether) very badly. He developed a pale cyanotic tinge and on two occasions stopped breathing. During the first four days after the operation he became progressively more pinched and ill in appearance with a clammy skin and a constant hiccup. The abdomen was tense and distended. His pulse remained slow (68) and he did not vomit. On the fourth day his condition appeared desperate. His hands and face were cold and clammy, his eyes sunken, yet his pulse remained slow. A stomach tube was passed and 8 pints of orange-coloured foul-smelling fluid

were withdrawn. On the supposition that he had an acute duodenal ileus the stomach tube was left in he was turned on his face and the foot of the bed was raised. This, however, effected no improvement and repeated "washing" out of the stomach always brought away large quantities of foul smelling yellow fluid. It was decided therefore that the obstruction must be below the duodenum and on the morning of the fifth day after operation the abdomen was opened to the left of the umbilicus under local anaesthesia. A gas filled coil of small intestine presented and into this a rubber tube was

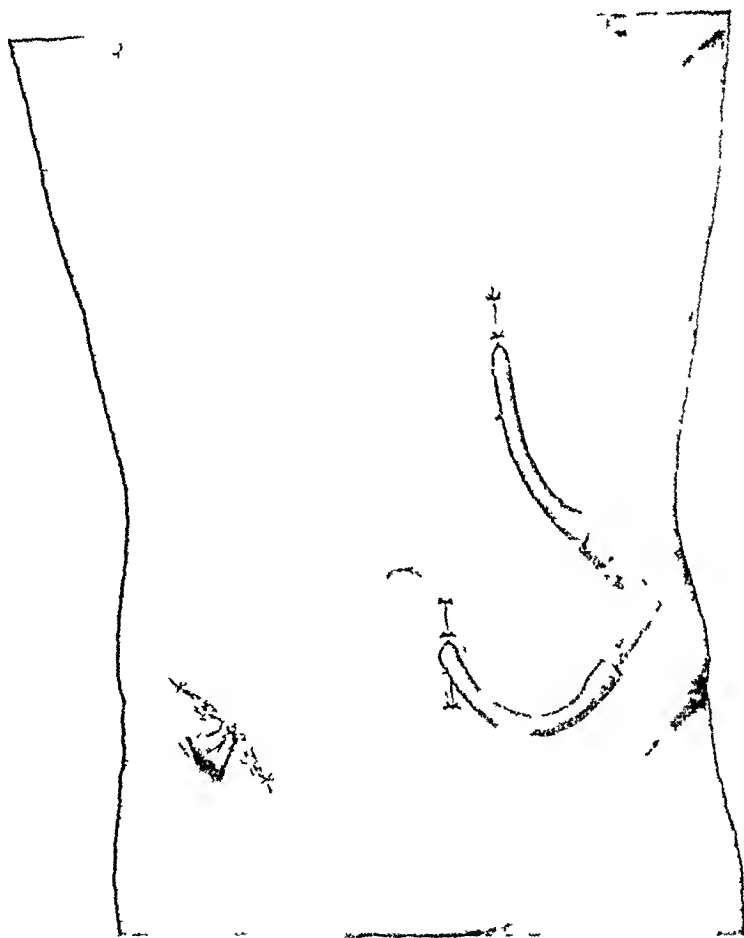


FIG. 321.—Upper tube drawing first coil of jejunum connected up with lower tube entering coil of small intestine below the obstruction. A constant stream of content passed through this circuit for five days.

fixed after Witzel's method. Some gas, but practically no intestinal content, came away, but large quantities of glucose solution and peptonized milk were given through the tube. The stomach tube still brought away a great amount of faeculent material, and it was clear that the enterostomy had been made below the seat of the obstruction. During the succeeding eight hours the patient sank perceptibly and was obviously dying from obstruction. Therefore at 8.0 p.m. on the same day a further attempt to relieve him was made

Under local anæsthesia an incision was made in the epigastrium through the outer border of the left rectus muscle. To make certain of being above the obstruction the highest coil of jejunum was sought for, identified, and pulled up to just below the abdominal wound. A rubber tube was inserted into this after the method of Witzel, and immediately there was a copious escape of foetid yellow fluid exactly like that which the stomach tube brought away from the stomach.

Over-night and throughout the next day there was an almost continuous stream of fluid content through the tube, and in spite of the fact that fluid nourishment was being given at three-hourly intervals through the lower tube, the patient was emaciating at an alarming rate. There was still regurgitation from the stomach, which was washed out twice daily.

One was now faced with the fact that the patient was threatened with a physiological death from loss of duodenal secretion. To obviate this an attempt was made to preserve and utilize the duodenal secretions by injecting the fluid nourishment into the first jejunal coil and the duodenum through the upper tube and then immediately connecting the latter by means of an L-shaped glass connecting-tube to the lower rubber tube (*Fig 321*). This was found to work admirably, for the distended upper bowel immediately emptied itself through the rubber tube into the intestine below. This manœuvre carried out two-hourly was followed by an immediate and most remarkable improvement in the patient's general condition. The glazing of the skin and the stuporose condition into which he had sunk both changed with notable rapidity, and he expressed himself as going to recover. For another forty-eight hours, however, the stomach tube was required, as some regurgitation was still going on.

It was now seen that quite independently of the foods given through the upper tube there was an intermittent but rapid flow of intestinal juice going on through the tube, which was obviously functioning as a coil of intestine. Liquid foods were now given by the mouth and could be traced coursing rapidly down through the tube as peristaltic contractions pumped the fluid through.

Thus for five days the artificial intestinal loop functioned. At the end of that time a slight leak occurred at the upper tube, and, as the patient's condition was now good and his bowels had acted on several occasions, it was decided that in all probability peristalsis would now be able to establish intestinal flow by the normal route. Both tubes were now withdrawn and a dose of castor oil was given by the mouth. To our pleasure and surprise there was a copious natural evacuation and very little escape from the jejunal fistula. The bowels continued to act normally, the fistulae closed within two weeks and the patient rapidly gained in strength and weight, and two months later had resumed his work as a schoolmaster.

This case brought home several points of importance. (1) The necessity for high jejunal drainage in cases of obstruction from peritonitis. (2) The danger from loss of fluid and starvation, with a high fistula. (3) The possibility of tiding a patient over the critical stage by an artificial anastomosis between the obstructed bowel and a coil below the seat or seats of the obstruction, by means of a tube outside the abdominal cavity.

VISITS TO SURGICAL CLINICS AT HOME AND ABROAD

PROFESSOR THORKILD ROVSING AND THE RIGSHOSPITAL AT COPENHAGEN.

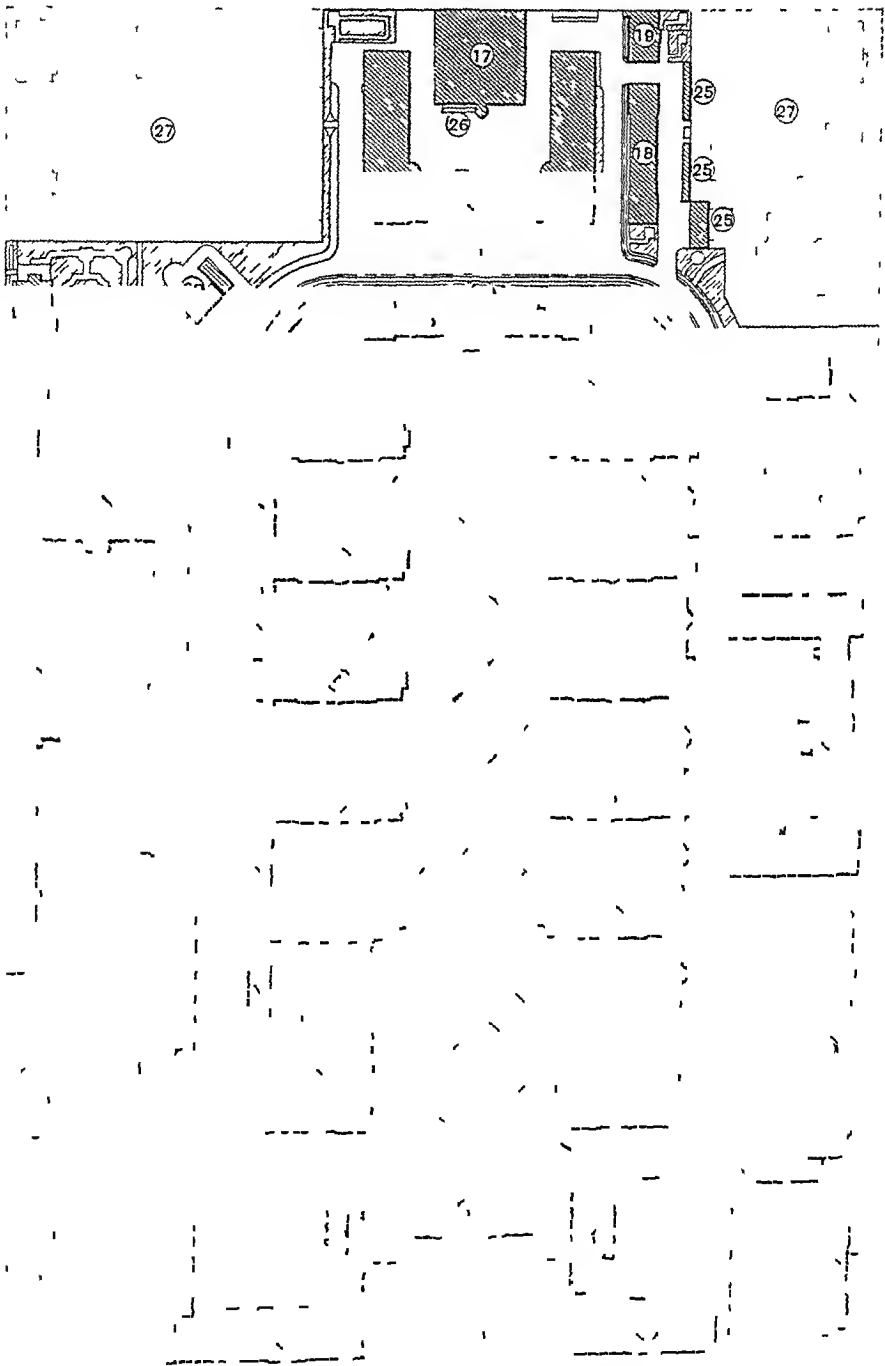
THE Rigshospital is the chief University State Hospital of Denmark. Situated in the northern suburb of the capital and occupying an extensive site, it represents one of the most up-to-date and perfect hospitals in the world. It contains over 1000 beds which are distributed as follows —

- Two medical services with 280 beds
- Two surgical services with 280 beds
- One maternity and gynecological service with 283 beds
- Children's diseases with 62 beds
- Ophthalmic diseases with 20 beds
- Aural diseases with 17 beds
- Dermatological diseases with 81 beds

The hospital was built during the years 1905 to 1910 at a cost of nearly ten million kroner (£500,000). It is constructed on the pavilion principle. The surgical and medical services are each accommodated in a series of six buildings connected by a long corridor, and these two groups of buildings face one another across a well-kept garden. The special departments, nurses' quarters, professors' houses, and administrative buildings are grouped round the centrally-placed medical and surgical departments. The whole associated group of buildings occupies a site of 300 by 400 metres (*Fig. 322*).

The hospital is a State institution and a department of the University. About 90 per cent of the patients pay a sum towards their maintenance, which costs 13 kroner (10/6) a day. About 50 per cent pay 2 kroner, 33 per cent pay 4 kroner, and 7 per cent pay 12 kroner a day towards this maintenance charge. Thus there is an annual charge of nearly 3½ million kroner (£136,000) representing the deficit of income as compared with expenditure, to be defrayed by the State.

The surgical service of the hospital consists in two departments of equal size (140 beds). Each is under the direction of a professor, who has two assistants and three house surgeons, as well as one pathologist under his direction. The two professors of surgery are Professor Rovsing and Professor Schaldemose. The wards, arranged on two floors, are much subdivided, the largest contains only 16 beds and is subdivided into four parts by a central gangway.



GENERAL PLAN OF THE PIGSHOSPITAL

and by mahogany partition about eight feet high so that not more than four patients are associated together in any part (Fig 323)

The operating department (Fig 324) of each surgical service consists of two sets of operation theatres and sterilizing rooms arranged in series. One theatre contains two tables and the other contains one so that three operations can be arranged simultaneously. In addition to these operating rooms there is a large well-lighted amphitheatre for demonstration purposes with terraced seats to accommodate about two hundred students.

On the occasion of a recent three days visit Professor Rovsing began each day by giving us a short lecture in the amphitheatre and then performed a series of operations. In the afternoon he took us to other departments of the hospital where we had special demonstrations. In his introductory remarks he described some of the points of general surgical technique. In regard to general anesthesia ether only is used and it is given by a simple closed inhaler (Wauscher's) consisting of a face-piece and a rubber bag.

DESCRIPTION OF GENERAL PLAN OF THE HOSPITAL

- | | | |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 Administrative block
5 Medical pavilions general wards
7 Service of ophthalmology
9 Service of otolaryngology
11 Service of skin diseases
13 Paths
15 Chapel
17 Workshops
19 House for the Professor of Obstetrics
21 Houses for the two chiefs of the medical service
23 Receptacles for kitchen refuse
27 Departments of general pathology, pathological anatomy etc | 2 Surgical theatre
4a Surgical pavilion, private wards
5a Medical pavilion private wards
8 Polyclinic of children's diseases
10 Service of obstetrics and gynecology
12 Kitchens and laundry
14 Service of disinfection
16 Houses for the Director and one of the chief surgeons
18 Houses for the two chiefs of the medical service
20 Cycle shed | 3 Medical theatre
4b Isolation ward
5b Isolation ward
6 Service of surgery and medicine
9 Service of children's diseases
12 Nurses' quarters
17 Central
19 Staff quarters
22 House for the chief
25 Cycle shed |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

The antiseptic methods employed are of special interest, because it was in Rovsing's service that the principles taught by Lister were first most thoroughly applied. Iodine and iodoloin are not used at all, because they are regarded as useless and dangerous. Alcohol is now the chief chemical made use of for cleansing purposes with a phenol compound known as phenosalyl. Nitrate of silver is extensively used in the form of a gauze, and this is employed over gutta-serena paper for the treatment of blennorrhoea and in the packing of deep wounds which require drainage. Formalin vapour is used for the sterilization of catgut and of instruments—for example, cystoscopes and catheters which cannot be boiled.

Another medicine of which Professor Rovsing has made special use is vaseline, this is injected into the joints of patients suffering from chronic forms of osteo arthritis. The first case in which the method was employed was for a lady with congenital dislocation of the hip, now some twenty years ago. It is of special value in simple osteo arthritis of the hip, where as many as 25 grammes of vaseline are injected by means of a Record syringe, and

the relief of pain which results lasts for as long as ten years although usually the injections have to be repeated at shorter intervals

In regard to the employment of drainage tubes, Rovsing makes frequent and varied use of the Pezzer tube. Thus he ties into the gall-bladder, or into the urinary bladder through a suprapubic opening, and he similarly employs it to drain a pleural empyema when it is attached to a gravity siphon apparatus. In this way he considers that the healing time of empyema has been reduced by 50 per cent. The Pezzer tube is also used for gastrostomy and colostomy.

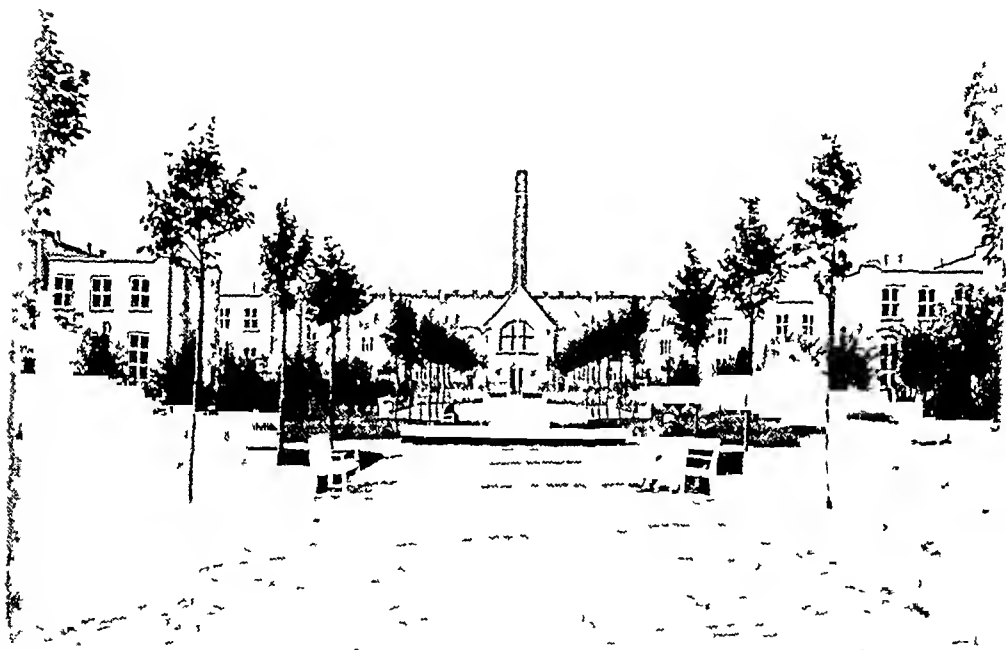


FIG. 322.—View of the exterior of the hospital and grounds

ŒSOPHAGOPLASTY

Cases of benign stricture of the gullet seem to be comparatively common in Denmark, where strong caustic alkalis are in everyday use for domestic purposes. Two patients were shown in whom a plastic operation had been done to remedy the occlusion of the œsophagus. One of these was a boy of 12 years, and in his case only the first stage of the procedure had been completed. This consisted in bringing the proximal part of the œsophagus up to the skin, just above the inner end of the left clavicle, and of doing a gastrostomy, the opening of which was near the ensiform cartilage.

The other patient was a woman of 25 who had had the plastic operation completed more than one year previously. After having an œsophagostomy

and a gastrostomy performed, is in the other case the two openings were connected by a skin tube running down the front of the sternum. Thus patient drank easily and the fluid wave could be seen passing down the front of the chest. Her general nutrition is good.

RENAL SURGERY

Royce is an ardent advocate of fixation and decapsulation operations upon the kidneys. He was probably the first to advocate decapsulation for certain types of nephritis in operation with which Edebohl's name is usually

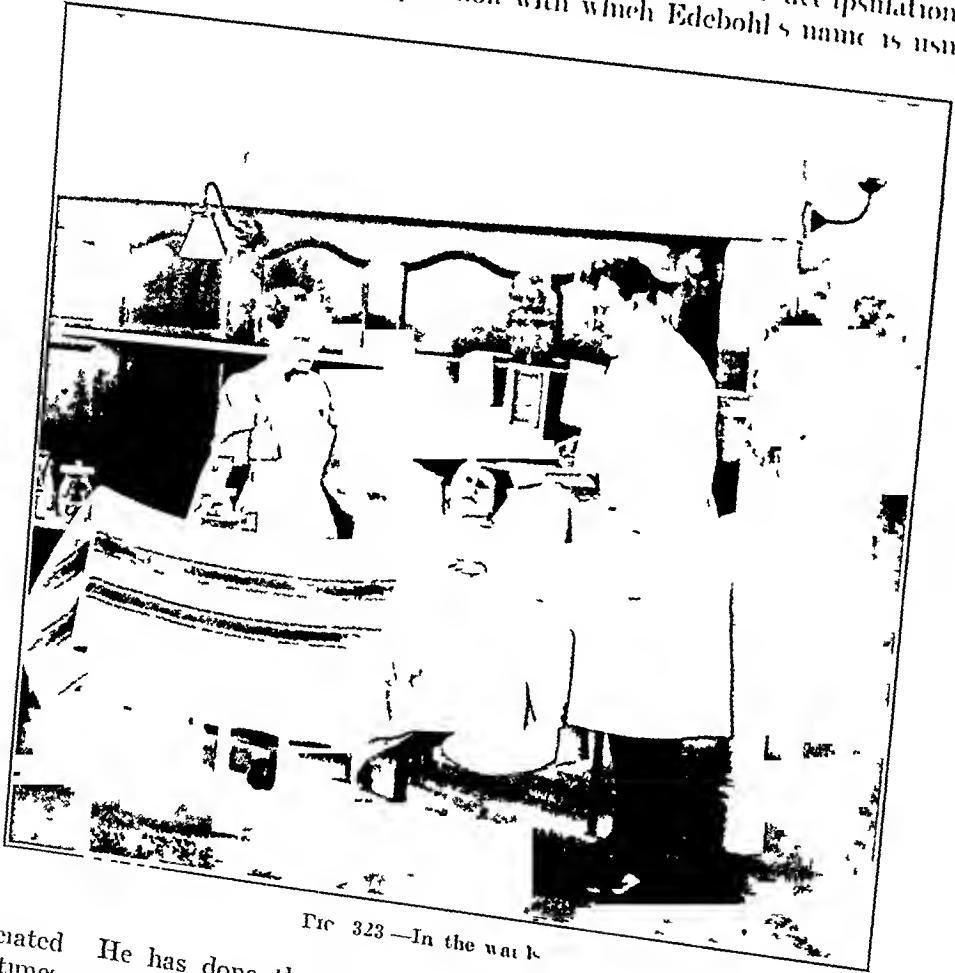


FIG. 323.—In the wait.

associated. He has done the operation which he calls 'nephrolysis' about 160 times, and is convinced of its value in all forms of nephritis, especially in the 'uratic' types, with attacks of pain and bleeding, here and in many cases of nephrosis full recovery was obtained. In cases of granular nephritis, albumin and blood in the urine diminish and the blood-pressure falls sometimes as much as 100 mm. In regard to fixation operations, he attaches great importance to full restoration of the dropped kidney to its normal position, and he specially deprecates sewing it to the rib, this, he states, is certain to cause pain even when it has not existed previously.

Renal Tumour Nephrectomy—(*Operation 11 55 to 12 15*) Female, age 52, who for some time had suffered from severe hæmaturia and had developed a right lumbar swelling. The patient was semi-prone and a transverse incision was made. A large kidney was quickly brought up into the wound. The ureter was ligatured in two places and divided with the cautery. The vessels were ligatured and cut without the use of clamps. A stout cigarette diam consisting of silver nitrate gauze in rubber tissue was put into position. The deep layer of muscles were united by catgut and the aponeurosis by fine aluminium bronze wire.

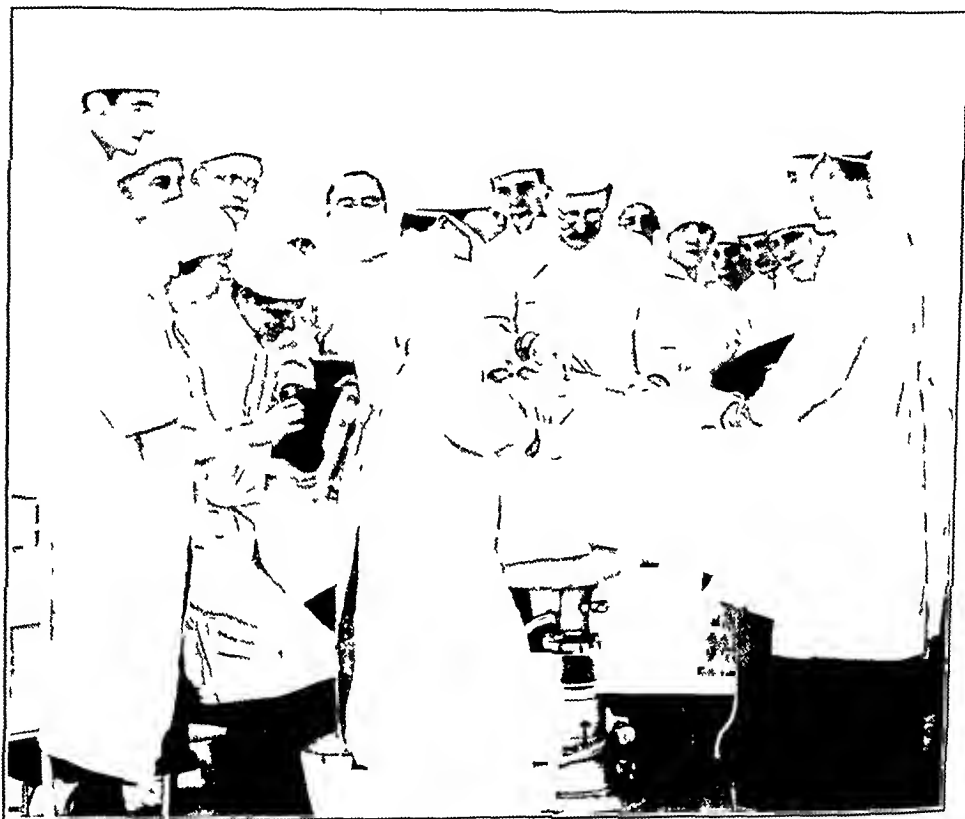


FIG. 324.—In the theatre.

Nephrolysis for Nephritis—(*Operation 12 15 to 12 30*) Female, age 38, who had been under medical treatment for albuminuria and hæmaturia for four years. Prone position. Transverse incision. Kidney, which was of moderate size, was brought up into the wound and its capsule stripped. A small piece of the cortex was taken for microscopical examination. The wound was closed as in the last case, round a cigarette diam. In this case only one kidney was operated upon at a time, but frequently both kidneys are decapsulated at the same operation. Rossing decapsulates the upper two-thirds of the kidney and lifts the organ up into normal position by one

silk suture in the remaining part of the capsule of the lower pole tied over a pad of gauze outside at the height of the tenth rib. This suture is removed after a fortnight.

Renal Exploration for Calculus—(Operation 11 22 to 11 50) Male age 44 had had repeated attacks of right renal colic. The X rays showed a somewhat doubtful shadow. Position and exposure is in the last two cases. Blood-vessels were twisted with Blinks's haemostatic forceps. The kidney was small and buried in densely adherent fat. The cortex of the kidney was incised, and through the incision the pelvis was explored with a snare forceps without result. The case was regarded as one of 'static' nephritis and decapsulation was performed.

ON THE PATHOGENESIS AND TREATMENT OF GALL-STONES

For many years Rovsing has held original views on the subject of the genesis of gall-stones and he has continued to advocate these views with his increasing experience. He chose this subject for his probationary lecture more than twenty years ago when he was a candidate for the professorship of surgery and he kept us keenly interested if not entirely convinced as he developed his arguments against the generally accepted theory of Naunyn.

That stasis and infection are not the prime causes of gall-stones he maintains on two broad grounds: first that neither stasis nor infection is present in the majority of cases when gall-stones exist and secondly that stasis and infection may exist for years without producing gall-stones at all. In every one of his 530 cases he made bacteriological examinations of the contents of the gall-bladder. He gives the following list of his gall-stone cases showing that in the majority the gall-bladder is actually sterile.

TYPE	NO. OF CASES	STERILE CASES PER CENT	INFECTED CASES PER CENT
Solitary stone	84	57	42
Large stone with several fractured stones	20	70	30
Multiple, round	117	62	37
Multiple, fractured	247	58	41
Pure black pigment stones	30	60	40
Biliary mud	4	25	75
Mud and stones	23	56	43

He thus disposes of the theory that infection is the prime cause of lithiasis. That stasis has nothing to do with it is supported by the fact that patients with gastroparesis and visceroparesis seldom have gall-stones. Moreover, in

infective jaundice both stasis and infection are present, and yet no gall-stones result

Rovsing drew our attention to the group of pure black pigment stones composed of bilhummin-chalk, a substance never found in normal bile. These small, prickled, branched concretions, which have been quite neglected by Naunyn and Asehoff as being irrelevant bodies, mostly found in the liver capillaries, are in Rovsing's opinion most important, being the beginning of every gall-stone. This appears from the fact that every gall-stone, round as well as faceted, so-called cholesterol or of mixed composition, if cut through, shows a nucleus of black pigment-chalk (bilhummin), round which the normal ingredients of the bile—cholesterol, bilnubin and biliverdin-chalk—have been deposited. The origin of gall-stones is usually, perhaps always, the precipitation of bilhummin-chalk in the liver cells, caused by a transient intoxication. Having entered the bile capillaries, the bilhummin is modelled in these into small, branched, irregular, black concretions which, owing to their shape, easily become entangled, lumped together, and get impacted in the gall-bladder or the ducts, where they grow by super-addition of cholesterol and bilnubin-chalk.

When the gall-bladder and ducts contain many stones, these are always of the same size, or belong to different 'bloods', each 'blood' containing stones of the same size, without intermediate sizes thus showing that a number of stones must be deposited at once, and he suggests that this is on account of a chemical, transient diathesis in the liver. That gall-stone patients are mostly females and women who have borne children arises from the fact that in pregnancy the liver undergoes some change such as the 'gravity liver' described by gynaecologists, together with intra-cellular pigment deposit, the beginning of gall-stones.

Other conditions, such as pneumonia, cancer, and osteomyelitis often precede the deposit of pigmentary gall-stones. Those who advocate the removal of the gall-bladder as the routine treatment for gall-stones regard the organ (1) as the native home of gall-stones, and (2) as useless, and point to such animals as the horse, which has no gall-bladder, as evidence that this structure is unnecessary. Now the native home of gall-stones is the liver, not the gall-bladder, and although the horse possesses no gall-bladder, he may have gall-stones so that the removal of the gall-bladder is no guarantee against lithiasis.

Rovsing believes that the gall-bladder is intimately connected with the proper secretion of the hydrochloric acid of the stomach, and that its removal leaves the sphincter of Oddi paralysed, with consequent achylia. In cases of cholecystitis or of gall-stones, therefore, the gall-bladder is never removed but only drained. The operation of cholecystectomy he reserves for cases of gangrene or cancer.

Cholecystostomy—(Operation 110 to 1120) Female, age 18, who had had two children, the last three months previously. She had severe attacks of colic during pregnancy and the diagnosis of gall-stones was made. An angled incision was made parallel to the right costal margin and down the middle of the rectus muscle. The rectus was split. The gall-bladder was distended and injected, it was grasped by two forceps and punctured by a

trocar, some thick bile being drawn off into a test-tube for bacteriological examination. The neck of the gall-bladder was held over a Mayo's spoon and the fundus opened showing a typical 'strawberry' appearance. The bile and mucus were removed, but no stone was found. A Pezzer tube was tied in and a silver nitrate cigarette drum packed round the gall-bladder. The wound was closed in layers.

Drainage of Gall-bladder—(Operation 11 55 to 12 10) A woman age 66 who had had repeated attacks of hepatic colic but no jaundice. The right rectus muscle was split. The gall-bladder was buried in adhesions and was thickened. The same technique was used as in the last case. No gall-stones were found, and the gall-bladder was drained.

ON GASTROPTOSIS AND VISCEROPTOSIS

Rovsing was one of the pioneers in the field of visceral ptosis and he remains to-day quite undaunted either by the general experience of disappointment with operative methods or by the variety of different procedures which have been suggested as a radical cure. He showed three patients upon whom he afterwards operated and while showing them made some general remarks about the conditions of visceroptosis. He has collected from his own experience and from the literature no fewer than 1291 cases which have been treated by gastropexy with the following results. Cured 75 per cent, improved, 14 per cent, not benefited 9 per cent mortality, 2 per cent.

In 90 per cent of cases the patients are women and of these there are two types which he describes as the 'virginal' (nulliparous) and the 'maternal' (parous). In the former the pain is much more severe and less easy to control by external pressure. In the maternal type he always first employs a Cantus belt, and operates only if this fails to give relief. In the diagnosis of the condition, reliance is placed upon the physical signs of the displacement including, of course, the X-ray appearances, together with the symptoms of pain, vomiting, and constipation, which strongly suggest gastric ulcer but are associated with a diminution of gastric hydrochloric acid. He first operated upon such conditions in 1897, placing a series of transverse sutures in the axis of the stomach, bringing the two ends out through the recti muscles, and tying them over a padded glass plate. Recently, however, he has employed the ligamentum teres in the manner described below. If the colon is also dropped and the gastriocolic omentum stitched, then this latter is reefed up by a series of stitches to the greater curvature of the stomach.

The first patient of this type that we saw was a female, age 26, married but with no children—a typical case of 'virginal' gastrioptosis. She began to menstruate at 12, and ever since that time has suffered from dyspepsia, with pain, vomiting, and constipation. The vomit frequently contained blood. The test meal showed normal acid contents. There was no stasis in the stomach. The X rays showed that both stomach and colon were very low in the abdomen, the latter lying in the pelvis. On examination there was a marked depression in the epigastrium, while the aorta could be

seen and felt pulsating. For some years she had been treated for gastric ulcer, and the appendix and right ovary had been removed. By the side of the umbilicus was the mark of a blister which was referred to as the '*carte de visite*' of the physician under whose care she had been for 'hysteria'.

Operation, 11 25 to 11 45—Median incision above the umbilicus. The liver lay with its margin well below the ribs and compressed laterally. The pylorus and duodenum were so mobile that they could easily be lifted out of the abdomen. There were some adhesions of the great omentum in the pelvis. The transverse colon was held up so as to expose the gastroduodenal band and show its vessels. Three catgut stitches were passed from the first curve of the stomach in and out of the omentum to the anterior longitudinal band of the colon and tied. The lower end of the ligamentum teres was cut, and the band was then stitched by silk to the lesser curve of the stomach. The free end of the ligament was brought through the left rectus and fixed by a silk suture. The abdomen was closed in three layers.

The second case was a female, age 11, married, with three children. After the first child she began to complain of dyspepsia and constipation. No vomiting. X rays showed ptosis of stomach and colon. The operation subsequently done for this case was identical with that just described.

The last case was a female, age 11, married, with three children. After the first child she began to complain of dyspepsia and constipation. No vomiting. X rays showed ptosis of stomach and colon. The operation subsequently done for this case was identical with that just described.

At the age of 11 he had had a severe crushing accident, and ever since had been suffering from dyspepsia, with marked vomiting and constipation. Had been diagnosed as a gastric ulcer, but the gastric hydrochloric acid was normal. The X rays showed that he had a large diaphragmatic hernia on the left side in which was a large part of the stomach and colon, extending as high as the level of the second rib.

Operation, 11 50 to 12 35—Mid-line incision above the umbilicus. Most of the small gut was drawn out of the abdomen and wrapped in hot towels. The liver was large and lay low in the abdomen. The omentum was very adherent to the opening in the diaphragm. It was ligatured and divided in several places. The left hand was pressed cautiously through the opening in the diaphragm. The stomach was drawn down, looking dilated and much congested. The colon was pulled down with even greater difficulty. The stomach was stitched by silk stitches to the margin of the liver. The great omentum and transverse colon were stitched to the great curve of the stomach. The ligamentum teres was used as an anchor to fix the stomach to the left rectus. No attempt was made to close the opening in the diaphragm. The small intestine was returned to the abdomen with great difficulty. The abdominal wall was closed in three layers.

OPERATIONS BY PROFESSOR SCHALDEMOSE

Professor Schaldemose who has charge of one of the surgical services was good enough to allow us to witness three operations. The first case was one of cerebral cyst. The patient was a male, age 7, with headache and left facial paralysis and choked discs with three diopters of swelling.

Operation 815 to 830—The head had been completely shaved. The guiding lines for the right Rolandic area were marked by the pressure of a tight string pressed over the scalp. The flap over the area was surrounded by a looped silk ligature which acted as an efficient hemostatic. A bone-flap was formed by means of four bur openings connected by a revolving osteotome. These were worked by a powerful overhead motor. The dura was divided by a crucial incision, and as it was cut a large quantity of thick dark fluid escaped from the cyst beneath. The dura and skin were closed by interrupted catgut sutures. The hamostatic silk stitch was left in place in the skin but it was cut in four places.

The second case was parenchymatous goitre in a female age 18, who had had a large goitre for many years, it had caused no symptoms but had become very unsightly. The neck had been infiltrated by $\frac{1}{2}$ per cent novocain followed by 1 per cent injected over the principal nerves.

Operation 830 to 855—Collin incision. The goitre affected chiefly the right lobe. The infrahyoid muscles were divided, the tumour was brought up by means of a shoehorn spatula. The vessels were ligatured and divided and the tumour was removed after cutting through the isthmus. The wound was drained.

In the third case cholecystectomy was performed for gall-stones in a male, age 50, who had had three attacks of colic. Oblique incision made below the right costal margin. The gall-bladder was much enlarged and adherent. It was first separated from the omentum and then from its bed in the liver. The cystic duct and artery were clamped and divided. The gall-bladder was thickened, and measured about 3 by 1 in and was filled with a number of gall-stones. The common duct was probed through the cut end of the cystic duct but nothing further was found. A drainage tube was passed into the common duct and a second drain was placed in the peritoneal cavity. The wound was closed in four layers.

SOME OF THE SPECIAL DEPARTMENTS OF THE HOSPITAL

It is impossible in the space at our disposal to do justice to the many highly specialized departments of the hospital, but we were much impressed by their splendid arrangement, and still more by the enthusiasm of those in charge of them. One of the most notable departments is the Finsen Institute, where the work of this great scientific observer is still carried on with increasing success. Dr Chievitz showed us the kind of work which is being done here for tuberculous joints. Every case of tuberculous disease is treated by the Municipality. Suitable early cases of bone and joint disease get the general light bath given three times a week for two and a half hours at a time. It was a remarkable sight to see these nude patients in groups of four or five roasting themselves round three huge carbon arc lights, their eyes shaded by dark glasses, then skins deeply bronzed and pouring with perspiration. There are 80 in-patients in the light department, and a daily attendance of about 150. The treatment is continued for two to four years and all cases are followed up for several years later.

Good results were shown in tuberculous ankles, elbows, shoulders, and

knees in children, but it was remarkable that no splints were used except for the temporary relief of pain

Dr Fibiger, who is in charge of the Pathologico-anatomical Institute, gave a most interesting demonstration of the artificial production of cancer in rats and mice, the stomach cancer in rats caused by a nematode worm, and the tail cancer in mice

Dr Fischer in the Institute of General Pathology demonstrated the culture of epithelial and connective tissue *in vitro*

It is impossible to close this brief account of a visit to Professor Rovsing at the Rigshospital without expressing admiration for the organization, equipment, and personnel of this great State Hospital. The enthusiastic and cordial co-operation of so many workers in the task of scientific healing was most impressive. Our special thanks are due to Professor Rovsing and his colleagues and also to the Director of the Hospital, M. Olgaard, all of whom lavished upon us information, kindness, and hospitality.

SHORT NOTES OF RARE OR OBSCURE CASES

MALIGNANT PAPILLOMA OF RENAL PELVIS ASSOCIATED WITH CALCULUS,

By GEOFFREY HADFIELD, BRISTOL

MALIGNANT new growth of the renal pelvis is an uncommon tumour and of the 54 recorded cases calculus was found in only 10¹. The pathological changes accompanying calculous pyelitis would seem from analogy with those found in cholelithiasis to predispose strongly to malignancy and the apparent rarity of this complication is all the more striking in the light of the fact that the continued presence of a calculus in the renal pelvis may cause leukoplakia of its epithelium².

A woman, age 48, was admitted to the General Hospital Bristol complaining of pain in the back and a lump in the abdomen. Fourteen years before admission she had an attack of painless hæmaturia lasting several days. She enjoyed fair health and freedom from hæmaturia for thirteen years after this, then she had another attack of hæmaturia lasting four weeks and accompanied by lumbago pains "right across the back". These symptoms gradually subsided, and she was free from trouble for twelve months, i.e. until a fortnight before admission, when, following a slight knock on the left side, she had an attack of acute lumbar pain and vomiting, followed the next day by profuse hæmaturia. On admission, the hæmaturia was subsiding.

CONDITION ON ADMISSION—A painless hard tumour the size of a fist was found in the left hypochondrium, moving slightly with respiration. The upper border was 1½ in. below the costal margin, and a hand could be passed up between the tumour and the lower ribs. No kidney could be palpated on the left side in the normal area. The right kidney was not felt. The urine was faintly acid and turbid. The deposit was purulent and blood-stained. No crystals, casts, or epithelium were found. Many red blood-cells and leucocytes were present. A pure growth of *Bacillus coli* was obtained on culture.

The kidney was excised, the ureter being tied off just below its lower pole. The wound healed, but twelve days after the operation broke down, firm union finally following after three weeks' suppuration.

Two and a half years after this operation the patient was readmitted for persistent discharge from the wound and an irregular painless mass was palpated from the abdomen in the position of the excised kidney. The urine was blood-free but purulent and gave a heavy growth of *Bacillus coli*.

The abdomen was opened and a large mass of growth found it was firmly attached to the posterior abdominal wall and adherent to the descending and transverse colon. It was considered inoperable. The patient died a few months after this operation, no post-mortem examination was performed.

PATHOLOGICAL REPORT ON KIDNEY—The renal pelvis and calices are greatly dilated by blood-stained fluid, and the kidney tissue is reduced to a shell about $\frac{1}{2}$ in thick. The wall of the pelvis is greatly thickened but quite

smooth. Lying at the lower pole of the kidney in the position of its lowermost dilated calices, is a large tumour mass roughly spherical in shape and $2\frac{1}{4}$ in diameter, in the centre of which lies a spherical mulberry calculus $\frac{3}{4}$ in diameter. The tumour appears to have grown around the calculus as a nucleus and extends chiefly backwards and inwards, infiltrating the lower pole of the kidney. It bulges the pelvis from below but has not infiltrated its wall except at the uretero-pelvic junction, where the pelvis and ureter are lost in the growth. The free edges of the tumour and of the cavity in which the calculus lies are beset by innumerable, small, vascular, papillary fringes. The centre of the tumour is white and firm, and on section is seen to be intersected by faintly indicated branching bands of translucent fibrous tissue from which spring closely-set papillary masses of growth. This pattern on section is lost in the posterior part of the tumour, where it has pierced the lining of the contained calices; here it is homogeneous, firm and white and an incomplete capsule



FIG 325.—Malignant papilloma of renal pelvis
($\frac{1}{3}$ nat size)

of muscle and fascia covers it externally. The tumour appears to have originated in the lowermost calices of a hydronephrotic kidney, around a calculus, has infiltrated the lower pole of the kidney and the adjacent perinephritic tissue, and has completely occluded the upper few inches of the ureter. (Fig 325.)

The microscopic structure varies considerably in different parts. Posteriorly where the tumour has infiltrated and destroyed the kidney, its characters are those of a rapidly-growing spheroidal-celled carcinoma except

that here and there some cell groups show a moderate degree of central keratinization. Towards its periphery and especially where the edge of the growth lies free in the distended calyx the structure is that of a simple papilloma, except that there is considerable irregularity in and nuclear hyperchromatism of the cells. (Figs. 326, 327.)

Sections did not show any renal metastases at a distance from the tumour, and there were no active inflammatory changes in the wall of the pelvis. No sign of pelvic leukoplakia was found.



FIG. 326.—Low power view, showing inflation of the wall of the dilated calyx of the kidney.

Miller and Herbst have collected 54 cases of papillary epithelioma of the renal pelvis and remark that of a series of 70 consecutive tumours of the kidney 2 only occurred in the pelvis.¹ In their 54 collected cases of papillary epithelioma, 10 were associated with calculus and 3 with infection. The growth varies from multiple bud-like isolated nodules to a single cauliflower-like mass distending the pelvis. One bilateral case has been reported.³ The growths tend to show varying degrees of histological malignancy in different parts.

Ewing⁴ describes these tumours as presenting two distinct types (1) simple papillary epithelioma suggesting a relation to benign papilloma, and (2) squamous celled carcinoma. Intermediate types have been described. The more pronounced papillary growths tend to invade the ureter and appear at the ureteric orifice of the bladder.

The majority are diagnosed in patients between the ages of 50 and 60.

Intermittent hæmaturia is often found. Clots may be present from urinary clots, but pain is not common. The hæmaturia is early (in one case four years, and in another seven years, before the condition was diagnosed). A palpable tumour was present in about one-third of the cases.³

The case reported here is apparently a transition type between papillary epithelioma and squamous-celled carcinoma. The absence of growth in the

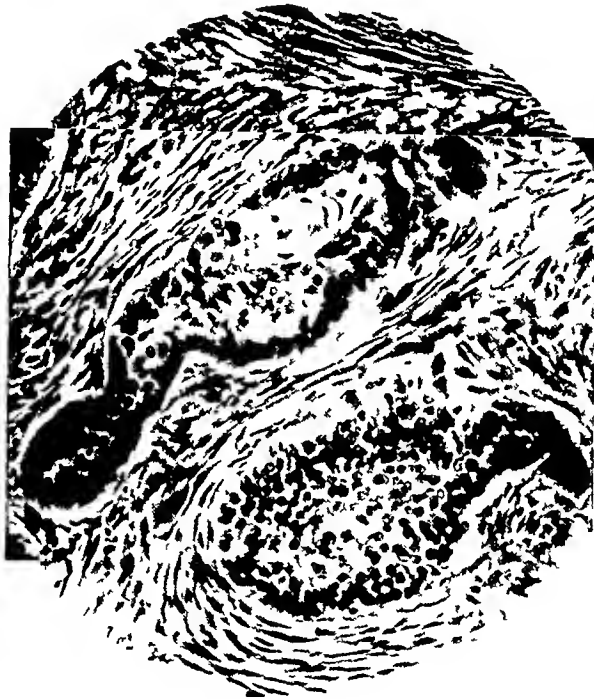


FIG. 327.—High power view, showing keratinization of cell masses of the growth

renal pelvis proper, with a growth of the dimensions described in the calices of the kidney, was striking. The great variability in histological malignancy and the slight but definite tendency of the cell masses to keratinize were the most salient pathological features of the tumour.

I am indebted to Mr R. G. P. Lansdown, Surgeon to the General Hospital, Bristol, for permission to publish the case.

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TWO CASES OF FATAL HÆMATEMESIS OCCURRING AFTER SPLENECTOMY FOR BANTI'S DISEASE

By DUNCAN WOOD BRISTOL, AND C S GIDEON, BATH

THE cases forming the subject of this report occurred at the Ministry of Pensions Hospital Bath, and are reported with the kind permission of the Ministry of Pensions, and of Professor Hey Groves to whose ward Case 1 was admitted

Case 1—Well-nourished man, age 32 Pale, with a chlorotic appearance In 1916, while in the Army he was found to be suffering from splenic anemia The spleen and liver were then noted to be enlarged, being $2\frac{1}{2}$ in and $1\frac{1}{2}$ in respectively below the costal margins There was no previous history of hæmatemesis He was discharged from the Army on July 10, 1917, as permanently unfit with splenic anemia which was recorded as attributable to service and exposure in the war

Splenectomy was performed by Sir Hugh Rigby at the London Hospital on Dec 12, 1917 The spleen weighed 1 lb 15 oz He made satisfactory progress after the operation, and his condition occasioned no comment until March 22, 1921 when he complained of abdominal discomfort followed in a couple of hours, by fainting Severe hæmatemesis occurred seven hours later

He was admitted to the Pensions Hospital the following day, March 23 when he again vomited $2\frac{1}{2}$ pints of dark clotted blood

A blood-count on April 1 showed —

Hæmoglobin, 48 per cent	Lymphocytes, 38 per cent
Colour index, 0.96	Large mononuclears, 10 per cent
Red blood corpuscles, 2,500,000	Basophils, 1 per cent
White blood corpuscles, 8800	Eosinophils, 1 per cent
Polymorphs, 50 per cent	

The red cells showed some variation in shape, but more in size, being mostly megalocytic There was some polychromatophilia and granular basophilia There were 55 normoblasts and 5 megaloblasts in 300 leucocytes

A later blood-count on August 10 showed —

Hæmoglobin, 90 per cent	Red blood corpuscles, 4,700,000
Colour index, 0.95	White blood corpuscles, 7600

After three five intervals of ten, four, and seven months respectively, hæmatemesis recurred On the last occasion he vomited about 6 pints of blood within thirty-seven hours, and then collapsed and died, on Jan 30, 1923 On admission on the last occasion his temperature was 100° , and it kept above normal until just before death

In December, 1922, a blood-count showed —

Hæmoglobin, 64 per cent	Lymphocytes, 54.5 per cent,
Colour index, 0.82	mostly of large type
Red blood corpuscles, 4,300,000	Large mononuclears, 10 per cent
White blood corpuscles, 5400	Basophils, 1 per cent
Polymorphs, 32.5 per cent	Eosinophils, 0.0 per cent

POST-MORTEM FINDINGS —

Stomach —Very enlarged, filled with fluid and clotted blood No ulceration of stomach No dilatation of vasa brevia veins

Œsophagus —Marked varicosity of veins around lower part of Œsophagus, with a large ruptured vein near cardiac end of stomach a clot partly filling its lumen

Spleen —This was absent, and its space occupied with omentum and fat which was very adherent to the diaphragm No accessory spleens

Liver —Marked multilobular emihosis Other organs pale but normal Small and large intestine filled with mæna

Case 2 —Regular soldier, age 30 In October, 1915, he was buried by the explosion of a shell, and suffered from hæmatemesis for two days Off and on after this he had slight attacks of hæmatemesis and was discharged from the Army on Dec 17 1917 with an enlarged spleen and disorderly action of the heart Between this date and his admission to hospital on Sept 7, 1920, for severe hæmatemesis, he suffered much from pain in the left side of the abdomen and epistaxis on stooping

On admission, his general condition was fair Pulse 110 There was no ascites or enlargement of the liver The spleen was found much enlarged Blood-count —

Hæmoglobin, 50 per cent
Colour index, 0.5
Red blood corpuscles, 4,560,000
White blood corpuscles, 4700
Polymorphs, 68 per cent

Large lymphocytes, 10 per cent
Small lymphocytes, 15 per cent
Transitionals, 3.4 per cent
Eosinophils, 1 per cent

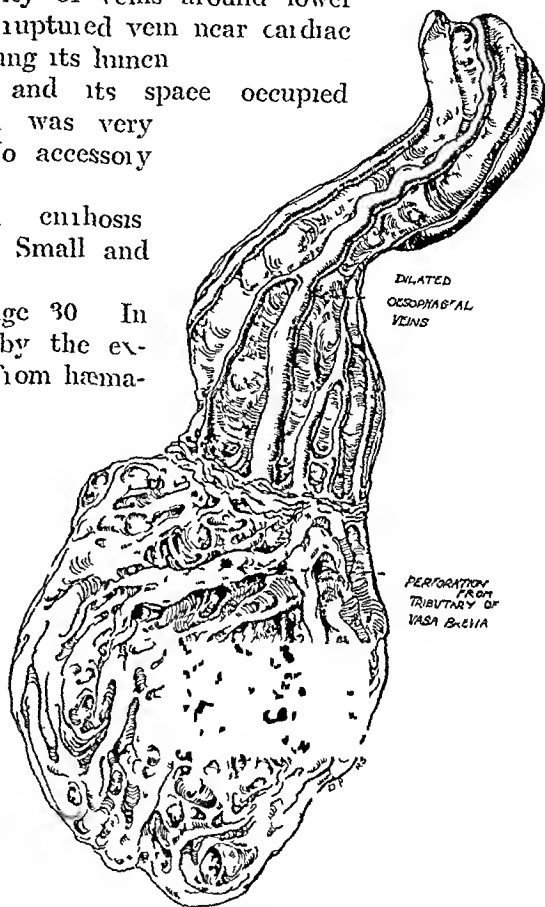


FIG. 328.—Case 2 Showing site of perforation of dilated vasa brevia vein through gastric mucous membrane

Splenectomy was performed by Mr. Duncan Wood on Oct 16 A vertical incision was made along the outer border of the left rectus abdominis The spleen was not adherent On breaking down the heno-phrenic ligament the spleen could be displaced outside the abdominal wall and was held there by gauze packed in behind The gastrosplenic omentum was then tied The pancreas was not adherent The spleen was turned forwards and the heno-renal ligament tied Bleeding was very slight during these manipulations Left lobar pneumonia complicated his recovery

There was marked improvement in the man's condition and a blood examination on Dec 10 showed —

Hæmoglobin 70 per cent
Colour index, 0.7 per cent
Red blood corpuscles 5,000,000
White blood-corpuscles, 20,000

Polymorphs, 52 per cent
Lymphocytes, 30 per cent
Large mononuclears, 11 per cent
Eosinophils, 3 per cent

At 9 a.m. on June 16 1921, he had an attack of hæmatemesis, following one month's feeling of general indisposition and was admitted to hospital

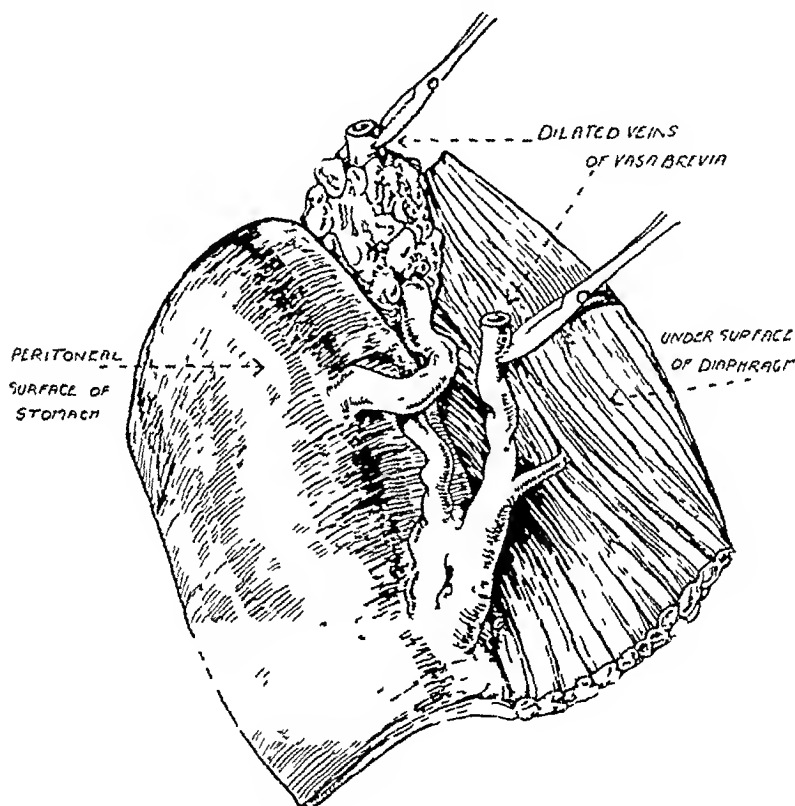


FIG 329—Case 2 Dissection of peritoneal surface of stomach to show dilated vasa brevia veins

He gave the history of having vomited about half a pint of unclotted blood. He showed no signs of collapse. Temperature 99° Pulse 120. He was treated with subcutaneous injection of 10 c.c. horse serum and morphia hypodermically. Twenty-four hours after this attack, he vomited 1½ pints of blood, light-red in colour, with few clots. This was followed by two severe attacks of hæmatemesis on June 19, when he died.

POST-MORTEM FINDINGS —

Stomach—Much dilated and full of fluid and clotted blood. A large open varix was found 1½ in. below the œsophageal opening at the cardiac end (Fig 328). The vasa brevia veins were enormously dilated, as is well shown in Fig 329.

Œsophagus—Large varices around its lower end.

Liver—Smaller than usual Multilobular cirrhosis

Spleen—Absent No accessory spleens

The above cases are of interest for the following reasons—

1 The time of the occurrence of the hæmatemesis in the two cases *Case 1* had no hæmatemesis before the operation, and first suffered from this three and a quarter years after splenectomy, *Case 2* suffered both before and after the operation from hæmatemesis

2 Death occurring in *Case 1* five years and one month, and in *Case 2* eight months, after splenectomy—in both cases after an improvement in their condition had been noted

3 The diagnosis of the cause of the hæmatemesis in these cases, and the futility of an operation In this connection it is interesting to note that both the above cases gave a temperature above normal following severe hæmatemesis

4 *Case 2* presents all the features of recorded cases by Ledingham and Moynihan of splenic anæmia following severe abdominal injury

5 The question arises whether in these cases the removal of the spleen either prevents or retards embolic changes in the liver

CAST OF STOMACH FORMED BY A MASS OF FOREIGN BODIES PERFORATION

By C JENNINGS MARSHALL, LONDON

A M., a woman of 22, was seen at King's College Hospital on June 23, 1921 Twelve hours previously, during the night, she began to suffer from severe pain in the upper part of the abdomen near the ribs on the left Vomiting was stated to be 'incessant' this was very doubtful, as during the two hours under observation before operation she was observed to retch only a few times The bowels had been open that morning It was impossible to get a clear account of the preceding history The patient was of very dulled mentality the relatives stated she had had influenza six months before, and that for two months after this she had been queer, did not seem to know where she was, and had no memory of the period Four months ago—at the end of this illness—she had been admitted to hospital under the suspicion of appendicitis, but no operation had been performed Both before and after this admission she had suffered from indigestion and frequent vomiting after food Blood had not been brought up The appetite was good, but little food could be taken on account of the pain

The patient seemed in great pain, and sat and walked with the trunk flexed Heave and very occasional retching were observed The pulse was 88, the temperature 97.2° Two hours later these were respectively 104 and 98.8° The tongue was heavily furred, the palatal reflex absent The abdominal wall was held absolutely rigid in the upper part, in the lower the muscles contracted strongly in expiration Extreme and universal tenderness,

expressed by moaning and some shivering on the lightest palpation, disappeared on distracting the attention with the exception of invariable boarding of the upper recti. Apart from a large tympanic swelling in the right iliac fossa unaccompanied by any other sign there no further physical sign was made out. An enema produced a small hard mass of feces. There seemed to be an acute organic basis for the hysterical condition—possibly a slowly-leaking gastric ulcer.

Right paramedian laparotomy revealed a normal appendix and a caecum distended to the size of a fist. As the colon was traced onwards this distention disappeared without any obstructive cause being revealed. In the middle of the transverse colon a hairpin was found, one end embedded in the

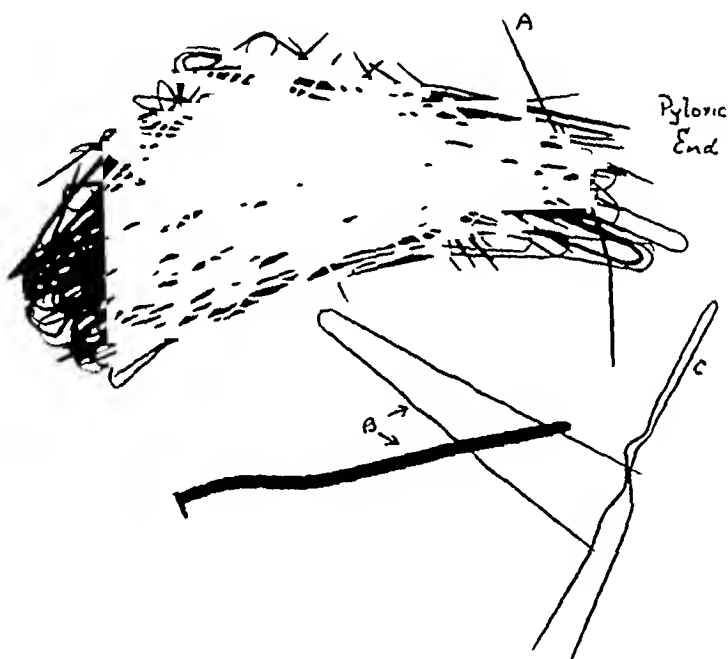


FIG. 330.—Radiogram of mass. A Needle perforating stomach, B Nail and hairpin detached during removal. C Hairpin removed from transverse colon.

mucosa, it was removed through a small incision. The distal half of the stomach was contracted and hard, and evidently occupied by an irregular mass. Projecting about an inch through the anterior surface about $1\frac{1}{2}$ in. below the lesser curve appeared a sharp stout needle, the other end emerging through the posterior wall just below the lesser curve. The two perforations, after withdrawal of the needle, were seen to be blackened and to be surrounded by a localized plastic peritonitis. There was no leakage of gastric juice, no free fluid. The posterior wall was over-sewn. After packing off, removal of the mass was attempted by an incision across its middle at right angles to the long axis of the stomach. So embedded, however, was its surface in the mucosa that a further cut had to be added, converting the gastrotomy into

an L shape. The stomach was then peeled off it. A raw, coarsely granular surface was left, oozing freely. A stump was removed for microscopy. The opening was closed in the usual way, a few ounces of 1-1000 acriflavine were poured into the abdomen, and this was closed after ascertaining as far as possible that there were no further foreign bodies in the viscera.

Convalescence was smooth. At the end of a week fish and chicken were eaten without discomfort.

A bismuth meal at the end of three weeks showed normal emptying of the stomach with a little rigidity and narrowing of the distal part. A needle was seen at the right side of the 1st lumbar vertebra, but as it had been impalpable in the corresponding part of the bowel, it was concluded that it was retroperitoneal and need not be removed. Seen later, the patient was in complete health, she had become normal mentally, but still had no recollection of the ostrich period of her life. Recently she writes "I have nothing to complain of, and feel perfectly well since my operation."

The intensely foul smelling mass removed consisted largely of hairpins (Fig 330), but there were also two locket chains, safety-pins, needles of various kinds, and one large nail which became detached from the mass during extraction. The whole was welded together by dark-brown mucus in which could be seen numerous grape skins and seeds. Erosion of the metal was very evident, the points were all extremely sharp, and the heads of the pins thinned, i.e. this occurred where there was contact with the mucosa. The pin lying across the long axis should be $\frac{1}{2}$ in nearer the centre of the mass, it was removed separately, and was responsible for the perforation. It seemed evident that the mass had remained the same for some considerable time, the degree of adhesion to the mucosa precluded the possibility of any recent addition. This, of course, fitted the history.

The microscope showed intense hyperæmia, great leucocytic infiltration of the submucosa, and intense catarrhal changes.

The case seems to show that trauma alone with superadded sepsis is not capable of initiating gastric ulceration. Here it produced an intense true gastritis—not the casually diagnosed 'explanation' of the majority of irritable gestions!—which, on removal of the cause, promptly healed.

SUBACUTE PANCREATITIS (ATRESIA OF THE PANCREATIC DUCT?) OCCURRING IN ASSOCIATION WITH ACUTE INTESTINAL OBSTRUCTION IN A NEW-BORN INFANT

By T. TWISTINGTON HIGGINS, LONDON

L. N. MALE, age 16 days, was admitted to the Hospital for Sick Children, Great Ormond Street, on April 26, 1922, under the care of Dr. Robert Hutchison, to whom I am indebted for permission to publish these notes. He was born a 'beautiful baby', but had vomited every feed since birth. The vomiting was forcible, the statement being made that the stomach

contents were pumped 'about a vaid' The bowels were said to have acted during the first two days of life thereafter they had been obstinately constipated The baby was always hungry He was breast-fed

FAMILY HISTORY.—Father and mother healthy Three miscarriages (at 6 and 8 weeks) Then followed the first child now aged 13 months and healthy The patient is the second living child

CONDITION ON ADMISSION.—A rather wasted infant, weighing 6 lb 8 oz but otherwise in fairly good condition Vomiting occurred after every feed taken profuse forcible and stained with bile After a feed gastric peristalsis could be well seen but no tumour could be felt Breast-feeding was continued in small quantities at short intervals and subcutaneous saline with glucose 2 per cent was administered concurrently Gastric lavage was instituted daily and the washings always contained bile

This treatment was continued for some days and the baby gained 6 oz in weight, but otherwise the condition remained unchanged the vomiting continued unabated and the gastric contents always contained bile The baby passed an occasional small brown undigested stool The case was regarded as one of duodenal obstruction

A radiographic examination was conducted by Dr Bertram Shmes who reported as follows —

The opaque meal was seen to pass into the stomach normally In a few minutes active peristalsis was observed, with no passage of food through the duodenum In 20 minutes practically no food had left the stomach In 45 minutes traces of the meal are seen in the small bowel There is a persistent shadow in the duodenum In 4½ hours only a quarter of the meal has left the stomach

There is definite evidence of some obstruction The pyloric end appears normal, suggesting the obstruction is post-pyloric

OPERATION May 2.—A preliminary subcutaneous injection of saline with glucose 2 per cent was administered before operating—1½ oz into each axilla—and the stomach was washed out one hour before operation The anaesthetic employed was gas and oxygen The abdomen was opened by a mid-line incision above the umbilicus Some free fluid immediately escaped, which was distinctly milky in appearance The stomach and pylorus appeared normal, but the duodenum was dilated The jejunum and ileum were collapsed and empty The colon was of normal size, but the walls appeared very thin and yellowish in colour

There was evidently some obstruction localized at or about the duodeno-jejunal junction and on further investigation in this region a very remarkable condition of affairs was revealed

In the region of the pancreas and the root of the mesentery there was a diffuse, pultaceous-looking mass, greyish-white in colour and firm in consistence What appeared to be ducts, containing whitish milky-looking fluid were to be seen coursing over its surface, and there were several yellowish-white patches discernible in the vicinity, dotted over the surface of the mesenteries rather suggestive of the patches of 'fat necrosis' in acute pancreatitis

The duodenojejunal flexure was bound up in this mass, and the gut was obstructed at this point The jejunum came away from this fixed attachment

as though completely twisted on itself and the distal gut was tiny and quite empty (Fig 331)

It was decided that any attempt to free the gut would be unwise, and accordingly a posterior gastro-enterostomy was performed by the customary method. The abdomen was closed in layers. At the completion of the operation, the baby's condition was very fair, and, despite a few critical days, he rallied well from the somewhat prolonged intra-abdominal procedure. The wound healed aseptically and the stitch was removed on the eighth day.

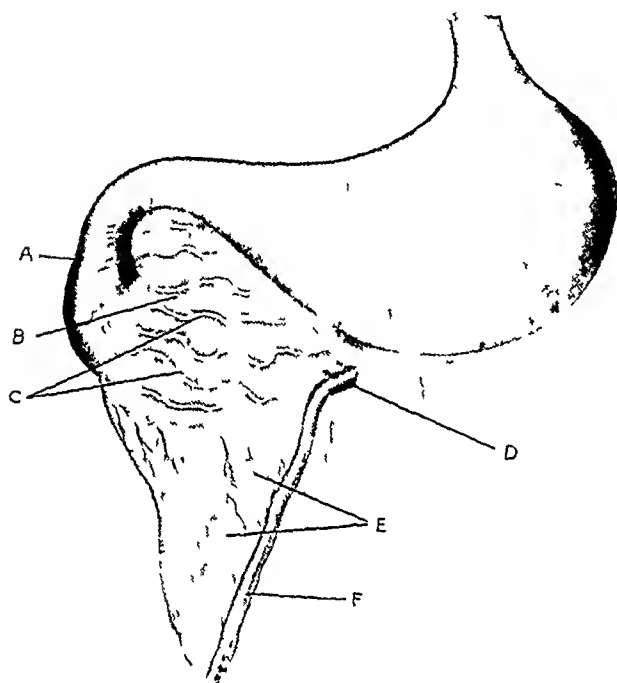


FIG 331.—Partly diagrammatic drawing showing the condition. A Duodenum dilated. B Pancreas. C Dilated ducts. D Site of obstruction. E Patches of (?) fat necrosis in mesentery. F Small intestine (collapsed).

Convalence, however, was very prolonged and tedious. Vomiting continued for a considerable time, though in diminishing degree, and it was not until June 21 (i.e., seven weeks after operation) that gastric lavage was finally discontinued.

Thanks to the most skilled and attentive nursing and very careful dieting, the baby gradually strengthened its hold on life. The vomiting slowly waned, the stools became more normal in quality and quantity, and clearly the short circuit was functioning satisfactorily. But despite these satisfactory signs the baby's weight on July 4 (two months after operation) was only 5 lb 10 oz. The weight record affords one of the chief features of interest in the case. The post-operative fall from 6 lb 13 oz on May 1 to 5 lb 10 oz on May 21 is

R	Pepsin	gr J	} 5ss after each feed
	Pancreatin	gr J	
	Ol Caryoph	℥ 2/3	
	Mist Bism	5J	

noteworthy, and the weight remained unsatisfactory for two months, until the administration of pancreatin began on July 9. Almost immediately the child began to gain weight. On Aug 3 he weighed 7 lb 2 oz. He was discharged home on Aug 11, 1922, weighing approximately 7 lb, feeding on 'Cow and Gate Mixture' and pancreatin. He has gone steadily ahead ever since, the only setbacks occurring when the pancreatin mixture was discontinued. It was only found possible finally to drop this about three months after his discharge. The baby is now fat and well and appears quite normal.

COMMENTS

This is a case of great interest which is not a little difficult of explanation. Was the intestinal obstruction primary and the pancreatic condition secondary, or was the obstruction due to a primary pancreatic lesion? The former view would seem more probable. The obstruction was situated at or about the duodenojejunal junction, the duodenum itself, so far as it could be seen, showed no external evidence of abnormality. The absence of jaundice clinically and the constant presence of bile in the stomach contents, showed that the bile-duct was patent. Under these circumstances the chances of an atresia of the pancreatic duct alone having existed seem remote, though not impossible. According to Keith¹ the pancreas is developed from two processes, each carrying with it its own duct. The ventral process arises in close association with the liver bud and its duct the duct of Winsung is intimately related to the bile-duct. The dorsal process which is larger carries with it its own duct the duct of Santorini. Normally the terminal portion of the duct of Santorini disappears, and the secretion of that segment of the pancreas developed from the dorsal process is poured into the duct of Winsung. Nevertheless occasionally the duct of Santorini may persist in its entirety and open separately into the duodenum. Further it may happen that the duct of Winsung does not join the common bile-duct in the normal way, but opens separately into the duodenum.

It will thus be seen that there are possibilities of atresia of the pancreatic ducts apart from a coincident atresia of the bile-ducts. The result of any such atresia would be that the whole or a major part of the pancreas would be deprived of an outlet for its secretions. The existence of such a state of affairs might conceivably give rise to the condition found in this case.

Nevertheless we are inclined to regard the pancreatic lesion as inflammatory, a subacute pancreatitis, secondary to a congenital obstruction in the vicinity of the duodenojejunal junction. The subsequent history of the case supports this view as the child is now developing quite normally and shows no sign of pancreatic insufficiency. The exact nature of the obstruction to the gut was not determined. There were considerable adhesions about the flexure, and these were not attacked. The small and large intestine were in their normal relationship and our conclusion was that an atresia existed somewhere in the terminal reach of the duodenum. Gastrojejunostomy was performed to relieve this.

Such a pancreatic lesion as that met with in this case, whether it be regarded as inflammatory or congenital, is rare, and one would imagine that recovery from it would be still more so. We therefore felt it should be placed on record.

REFERENCE

¹ KEITH, *Human Embryology and Morphology* 4th ed., 1921, p. 284

REVIEWS AND NOTICES OF BOOKS

Thyroid and Thymus By ANDREW CROTTI M.D., F.A.C.S., LL.D., Columbus Ohio
 Second edition Large 8vo Pp 774, with 105 illustrations in the text and 39 plates
 in colour 1923 London Henry Kimpton 70s net

THE second edition of this great work consists of over 700 pages divided into fifty-two chapters. Most of the first edition has been revised, and a great many chapters have been re-written. A good many new illustrations have been added. The author shows throughout that he has had extensive practical experience of the subject with which he deals, and is well acquainted with microscopical pathology and with surgical literature.

After chapters on the anatomy and physiology of the thyroid, there is a good discussion of modern views on the biochemistry of the gland. The chapter on pathology is illustrated almost entirely from microscopic sections, most of which are good, but *Fig 22*, supposed to represent a round-celled sarcoma, is scarcely recognizable as such. This chapter would be greatly improved by the addition of drawings or photographs of specimens from the operating theatre or from a pathological museum.

There is a long and good chapter on the etiology of endemic goitre and cretinism. The views of the principal writers on this difficult subject are well summarized. The author accepts as an established fact that the causative factor of goitre, whatever its nature is most frequently conveyed to the organism through drinking-water. He is not a believer in the theories which seek to establish a correlation between certain geological formations and endemic goitre.

He discusses at considerable length the rather fanciful 'Plutonian theory' of Requin, and, rightly we think, condemns it as "purely hypothetical." The author concludes, probably erroneously, that "heredity is an important factor in the etiology of goitre", a view not infrequently held. The belief of some modern authors that goitre is due to a deficiency of iodine in certain geographical areas he considers 'hardly acceptable.' The excellent work of McCarrison he discusses fully, and his final cautious conclusion as to the cause of goitre is that "so far the weight of evidence seems to be in favour of the infection theory."

The chapters on the medical treatment of simple goitre and on thyroid grafting are good. Chapter 20, on the indications for operation in simple goitre, shows the author to be an enthusiast for operation. Few surgeons experienced in this branch of practice would agree with him that thyroidectomy "must be undertaken in every case where medical treatment has failed" (p 323). Surely there are innumerable cases in which medical treatment fails to cure, but in which surgical treatment is nevertheless quite unnecessary so long as the goitre is doing no harm and is not likely to do so. The recommendation of operation for 'all colloid, fibrous, cystic goitres' apparently quite irrespective of whether they cause trouble or not, is too sweeping and will hardly appeal to a judicious surgeon.

The whole subject of exophthalmic goitre is treated at considerable length, and on the whole well. Graves disease is described (p 426) as "a thyro neuro poly-glandular disease caused by a toxic thyroiditis." Chapter 39, on the indications and contra-indications for operation, contains much excellent advice. A warning is rightly given against indiscriminate operating. "When once an operation has been decided upon, the judgment and experience of the surgeon will be largely the determining factors for the safe outcome of the case. Surgeons, because they have done too much, have killed a great number of patients with exophthalmic goitre."

Discussing the treatment of Graves disease complicated with pregnancy, the author expresses the opinion (p 423) that in bad cases "a premature Caesarean section may save the life" of the child. Even in much less severe cases he recommends a "timely thyroidectomy" as the "ideal procedure." We believe this to be trenching to which few surgeons experienced in thyroid surgery would subscribe. The statement that "Basedow patients before entering married life, should have thyroidectomy performed in order to safeguard them against any future exacerbations and to protect their future offspring," we believe to be unsound teaching, not justified by facts.

In his surgical technique of operations upon the thyroid gland (chapter 10) the author is at his best. Good descriptions of the various operations are given, together with the difficulties and dangers and the best means of avoiding them. The weak point in his case is that very little is said about the actual end-results of his, or indeed of anybody else's, operations, except by bare mortality tables which do not really tell us much. He seems to be a little too ready to conclude that recovery from the operation necessarily means cure of the disease.

In most operations for removal of simple goitre, he usually ties the superior thyroid artery, but does not interfere with the main trunk of the inferior, a proceeding which he rightly considers unnecessary and often harmful. His remarks on this subject (pp 530, 531) show sound common sense. On the other hand, the advice to give an injection of adrenalin after hemostasis has been completed "to diminish the chances of post-operative oozing" (pp 537, 538) appears to us to be a little dangerous. If the hemostasis has been really complete, adrenalin is unnecessary. If not, the use of this drug may easily induce in the mind of a less practised surgeon, a false sense of security since the constriction of blood-vessels produced by adrenalin can only be temporary.

The author speaks with a curious hesitation as to the comparative size of the superior and inferior thyroid arteries, whereas a very little acquaintance with museum specimens of goitre is sufficient to convince anyone that, with rare exceptions, the inferior is the larger artery. His impression that in "thyrotoxic goitres the superior seems to have a larger calibre" is certainly a remarkable statement, not confirmed by examination of the numerous specimens in English museums. His investigations into the number and position of the so called parathyroids (p 507) are interesting, and it is refreshing to find an American surgeon stating that "the stereotyped conception of two superior and two inferior parathyroids is far from being correct."

The chapter on anaesthetics is good. While recommending local anaesthesia for many cases, he gives the preference to ether when a general anaesthetic is to be employed. Intratracheal insufflation anaesthesia, "which seemed at first to be full of promise," he has found disappointing. "Just in the cases where it was expected to be the most useful, namely, in goitres with pressure symptoms, it failed to fulfil its expectations."

The last ninety pages of the book are devoted to the thymus gland. A good summary of the anatomy, physiology, and pathology of this organ is followed by an account of the surgical technique of thymectomy. The author is a strong advocate of the combination of thymectomy with thyroidectomy, and considers "this combined operation a great step forward in the surgical treatment of Graves's disease." It may reasonably be doubted, however, whether the operation of thymectomy is quite as easy or as safe as his artistic but semi-diagrammatic illustrations of the operations tend to indicate.

The bibliography, although containing many hundreds of names, is confusing and unsatisfactory. It contains long lists of authors arranged under the headings 'thyroid' and 'thymus' respectively, with reference to journals or other publications, but generally without mention of the subject of the paper or any reference to the places in the book where the author may (or may not) have been quoted. There are two indexes. One is a long list of bare surnames, with references to the pages of the book in which these names appear. The index of subjects is good. Three typical instances out of many of the author's rather slipshod methods may be given. On p 334 reference is made to the conclusions of "Goodall" (sic) VOL VI—A 43

in the study of 2250 cases of irritable heart. In the bibliography we find only the names of Goodal, A. and Goodal, J. R. (both names incorrectly spelt), and it is left to the imagination of the reader to ascertain to which of these the quotation in the text is to be ascribed. As a matter of fact, neither the Canadian nor the Scottish author has written on irritable heart, and the source of the statement in the text has obviously been Dr Strickland Goodall's Chadwick Lecture (*Med. Press and Circ.*, Aug., 1917) on 'soldier's heart', in which 2251 cases of irritable heart are analysed. No reference to the real source of the statement is given anywhere in the text of our author's book, in the bibliography, or in the index. Again, in the bibliography three different authors named Allen are mentioned without reference to the subjects on which they have written. There is no means of knowing with which of these authors the only Allen of the index and text (pp. 446, 636) is to be correlated. Lastly, an observation of Nivet's (misspelt Nevet) concerning the seasonal occurrence of epidemic goitre is somewhat incorrectly quoted on p. 256, but neither in the text nor in the bibliography is any mention made of this author's excellent book, *Traité du Goitre, appuyé sur des Documents statistiques inédits*, a mine of useful information, in which this observation was originally published.

The book is well got up, and misprints are few. Among them are 'teratomata' (p. 80) for teratoma, while on p. 36 the insertion of a comma between Swale and Vincent has unnecessarily bisected the eminent professor into two separate individuals.

The book contains numerous illustrations, many of which are very good. There is room for considerable improvement as regards anatomy in the drawings and diagrams illustrating operations. We do not remember ever having seen the inferior thyroid artery enter the thyroid in the position shown in Figs. 83 and 84, nor will the surgeon who attempts ligation of the superior thyroid artery for the first time obtain much practical help from the crude illustrations of this operation as given in *Plate XV*. *Plate VIII, Fig. 1* represents a large retrotracheal goitre springing apparently from the left thyroid lobe. If this be the case, the artist has placed the isthmus behind instead of in front of the trachea. Further, we are asked to believe that this great tumour "separated entirely" the œsophagus and the trachea, and lay between them. If so, the case is quite unique. Retrotracheal goitres are well known, but we believe that they always push the œsophagus to one side, and never pass between these two structures. Indeed, it is difficult to understand how embryologically they could possibly get into such a position. On the other hand, the drawing has been made from an operation case, and it is very easy, in the excitement of such an operation, to mistake the true position of the œsophagus, and we fear that the artist or operator has made such a mistake.

In spite of the numerous criticisms that we have been obliged to make, the book contains a great mass of interesting, useful information. It is a book that should be in the hands of every surgeon who desires to practise thyroid surgery. It is to be hoped that in subsequent editions there will be less about the opinions of others—especially when not derived from original sources—and that we shall hear more about the author's own cases, operations, and results.

Surgery of the Spine and Extremities By R. TUNSTALL TAYLOR, M.D. Professor of Orthopædic Surgery, University of Maryland and College of Physicians and Surgeons, Royal 8vo. Pp. 550 + 1, with 604 illustrations. 1923. Philadelphia: P. Blakiston's Son & Co. London: Stanley Phillips. 37s. 6d. net.

This book covers a great deal of ground, and the 500 or so pages of the volume do not seem to be sufficient for the purpose. While some of the chapters are comprehensive enough and thoroughly sound, it may be confessed at once that many subjects do not receive the attention they deserve, and in some instances the views expressed are not such as would receive general acceptance in this country. The book is patchy, and might have been written by two authors. Perhaps orthopædics is too big a subject for one man to cope with and write well on all the affections now always included in this branch of general surgery, and in the future we may see further specialization, though we trust this will not prove to be the case. Space being

limited, it is questionable whether the author is wise in devoting a chapter to historical notes, with copies of ancient illustrations, though no doubt the student will find interest in the dates appended to the names of many great surgeons of the past. A good many pages are devoted to plaster work, apparatus, etc., and precise directions are given as to the requisite quality of the materials used, and where these can be advantageously purchased—information which will no doubt be of the greatest service to the student in America.

As the plane of the ankle-joint is horizontal, we fail to see why, apart from obvious mechanical objections, when inside and outside steels are used it is advised that the joint of the outer should be at a lower level than that of the inner. Tuberculosis of the spine is dealt with fully. As might be expected, having regard to the nationality of the author, ambulatory treatment of spinal cases and the requisite apparatus are given more attention than they would receive at the hands of a British surgeon.

We think the reader would receive greater help if more definite directions were given as to treatment and if methods for which the author, in common with most surgeons, has no use were omitted altogether from the book. Scoliosis is fully discussed, the influence of faulty attitudes, etc., being particularly well described.

The chapter on hip disease suffers as much as any from the imperfections of the radiographic reproductions. Many of the radiograms throughout the book are too indistinct to be of the faintest use to anybody. We must again, as we had occasion to do in a recent review of another volume, draw attention to the undesirability, to say the least of it, when dealing with the subject of hip disease, of picturing a *single* Thomas hip splint, a splint which is entirely inefficient either for immobilization or the prevention of deformity. The author favours excision of a tuberculous focus in a bone adjacent to a joint when it shows signs of increasing in size in spite of immobilization of the joint. He would not, we think, be supported by many surgeons of to-day, particularly when he carries the idea to the extent of cutting through a healthy hip-joint to reach a focus in the neck of the femur.

As usual in a book dealing with orthopædic surgery, the subject of coxa vara is dealt with in a way which leaves the reader with no idea as to the author's knowledge or views. The sections on tuberculosis and other affections of the knee-joint are most disappointing. Apparently the only affection of the knee attributable to syphilis is a 'Charcot joint'. And again, in dealing with 'slipping patella', the intimate association of genu valgum is not even mentioned. The pages on flat-foot, on the other hand, are very well written and are thoroughly sound, and so are the chapters on infantile paralysis and spastic paralysis. In dealing with polyomyelitis a good account is given of what might be described as the non-orthopædic side of the subject.

Apart from the radiograms, the book is well and freely illustrated.

Diseases of the Rectum, Anus, and Colon including the Ileocecal Angle, Appendix, Colon, Sigmoid Flexure, Rectum, Anus, Buttocks, and Sacrococcygeal Region. By SAMUEL GOODWIN GANT, M.D., LL.D., New York. In three large 8vo volumes, with 1128 illustrations and 10 insets in colour. 1923. London and Philadelphia: W. B. Saunders Co. Per set £6 6s 0d net.

This book is not a revision of previous works by the author, but an entirely new work. As stated by the author in the preface, it is intended to furnish specialists, practitioners, and students with a complete treatise upon the diseases involving the ileocecal angle, appendix, colon, sigmoid flexure, rectum, anus, and perineal region.

The opening chapter contains a brief account of the embryology of the stomach, small intestine, colon, and rectum, and attention is drawn to the chief abnormalities resulting from imperfect development of the small and large intestine.

Chapter 2 deals with the anatomy of the rectum and anus. The description of the arteries and veins is excellent, but that of the lymphatics is rather confusing. Our view is that the lymphatics of the rectum are arranged in two distinct systems, the intramural and the extramural. These lymphatic systems determine the paths by which cancer cells spread from the rectum, and therefore a

clear conception of their anatomical arrangement is of vital importance to those who contemplate the surgery of the cancerous rectum

Chapter 3 draws attention to the various manifestations indicating the presence of anorectal disease, and the following chapter emphasizes the importance of making a complete examination of the patient in all cases in which rectal symptoms are present. Excellent illustrations of the various instruments in use for examining the rectum are given.

Chapter 6 is devoted to *mæsthesia*. The various methods of administering anaesthetics are fully discussed, as are also the various anæsthetic agents. The author evinces a strong predilection for local anæsthesia, for which he claims excellent results. He admits, however, that the method is not suitable for all cases, and gives lists of conditions that are favourable and unfavourable to its use.

Chapter 7 deals with malformations of the rectum and anus. The conditions depicted in *Figs* 122 and 123, in which the anus is shown to have been partially occluded by a fibrous band, must be very rare. The technique of the various operative procedures employed by the author in these cases is fully illustrated.

In chapter 15 fissure in ano is dealt with at considerable length. The author's operation of splitting the anal canal and sphincter seems to us to be a very drastic procedure, as it involves division of both sphincters and the levatores ani. In our experience a fissure can be permanently cured without even dividing any of the fibres of the external sphincter muscle.

In Chapter 17 the various abscesses that may be met with are fully described. The retrorectal abscess shown in *Fig* 218 is internal to the muscular coat of the bowel. A retrorectal abscess is not only external to the muscular coat of the rectum but is outside the fascia propria as well. We do not agree with the author's views in regard to the etiology of the superior perirectal abscess. In our opinion it is invariably due to puncture of the rectal wall by a foreign body from within, and the internal opening is usually situated above the level of the levatores ani and at a considerable distance above the interval between the sphincters. When, however, the abscess has subsequently invaded the ischio-rectal fossa, a second internal opening may be found to exist, in the middle line posteriorly, between the sphincters.

Chapter 18 is devoted to the consideration of anorectal fistula. We do not like the author's classification of fistula. Types and varieties are mixed up in a confusing manner. We cannot help feeling that the illustrations on page 320 are somewhat imaginative, as we do not recollect having seen a case of a horseshoe fistula in which the burrowing completely encircles the anus, as shown in *Fig* 239. The various methods of operating upon fistula are well described and illustrated. The technique of the various operative procedures is clearly stated but we question the advisability of producing an intussusception in order to cure a rectovesical fistula, as shown in *Fig* 277 because when an intussusception commences it usually increases in extent and eventually causes obstruction. Curiously enough, the type of fistula known as the perirectal is not described. As this is quite the most extensive fistula that is met with and is extremely difficult to deal with satisfactorily, a detailed description of the operative technique required in such cases would have been extremely acceptable in so comprehensive a work as this. In alluding to fecal incontinence after fistula operations, the author strikes a correct note when he says that loss of sphincteric control is more often due to faulty after-treatment than to the operation itself. It is a common practice to pack fistula wounds during the after treatment whenever they are dressed. A depressed furrow-like scar, extending into the anal canal results in, or is undoubtedly conducive to, incontinence.

In chapter 19 the method of treating internal piles by the injection of a solution of carbolic acid or of quinine and urea receives ample consideration. We agree with the author that this method is useful only in specially selected cases—that is to say, for piles in the first or early second stages of development. It is extremely rare that a permanent cure can be effected, relief being afforded only for a period of from one to two years. The several methods of operating for internal hemorrhoids are carefully described. There is no doubt that thorough exposure of all the existing piles is essential to success, but we cannot see the necessity of exposing piles by such methods as a suction pump or traction upon a tampon which has previously been

introduced into the rectum, when simpler means amply suffice for the purpose. We are in agreement with the author in his preference for the ligature operation, which in our experience yields uniformly good results. Whitehead's operation is deservedly condemned.

The opening chapter of Volume II deals with the important problem of control of bleeding from the rectum. We do not like the method shown in Fig 364, because it blocks the lumen of the bowel completely and does not provide a passage-way for the escape of flatus. Exception may also be taken to the methods shown in Figs 372 and 373.

Chapter 37 treats of procidentia of the rectum. Many operations for the condition are described and are abundantly illustrated. The author's excision operation appears to differ from Mickulicz's procedure only in the circumstance that he divides the outer layer of the prolapsed gut at some distance from the anus. When, therefore, suturing has been completed, a small portion of the original protrusion remains and has to be reduced at the end of the operation. This portion is apt to become reprotruded, so we prefer the Mickulicz method, by which the whole of the protruded portion of the bowel is removed. Fortunately for dwellers in Europe, the many forms of anorectal ulceration that are described and illustrated in chapter 38 are not often met with.

Chapter 39 is devoted to the important subject of pruritus ani. No new facts are forthcoming in the etiology of this troublesome complaint. We agree with the author in his condemnation of Ball's operation, but as his own button-hole operation performed under local anæsthesia is practically the same idea carried out in a slightly different way, we do not like it any better. We find that quite 80 per cent of cases of pruritus ani are due to definite disease in the anal canal, e.g., internal piles, ulceration of a Morgagnian crypt, fissure, hypertrophied anal papilla, and blind internal fistula, and that the operation which effectively cures these conditions also cures the pruritus. In about 10 per cent the disease is certainly the manifestation of a local neurosis. These cases can be cured by dividing the subcutaneous nerves as in Ball's operation, but symptoms usually recur in from six months to a year.

The succeeding chapters deal with such conditions as skin affections, tuberculosis, lupus, elephantiasis, venereal diseases, and unnatural sexual practices.

In chapter 46 the subject of stricture is fully discussed. The surgical measures advocated for the treatment of stricture are forcible dilatation, internal proctotomy, external proctotomy, excision, proctoplasty, and rectosigmoidostomy. We agree with the author that these procedures are seldom practicable or devoid of risk, and that when a stricture cannot be kept dilated by bougies much the safer plan is to perform colostomy. Chapter 47 is assigned to non-malignant neoplasms. In chapter 48 gas, faecal, and mucous cysts of the anorectal region are described.

We are disappointed with the chapters dealing with malignant disease. No attention is paid to recent work upon the spread of cancer of the rectum. These observations have clearly shown that an operation undertaken for the cure of cancer must be so planned that the operation field embraces the whole of the tissues that are pathologically known to be liable to invasion by cancer cells which have become detached from the primary growth. It is now recognized that cancer cells spread from the rectum chiefly by means of the extramural lymphatics, which are arranged into three distinct sets, viz., an upward, a lateral, and a downward lymphatic system. It has been established also that a cancerous growth, wherever situated in the rectum, may, while still in an early phase of development, give rise to metastases in either of the three lymphatic areas, or in all of them at the same time. Hence the various tissues through which these lymphatics pass must be regarded as being highly dangerous, and they must be widely removed whenever an operation is undertaken for cancer of the rectum. Failure to appreciate these facts in regard to the spread of cancer from the rectum no doubt explains a surprising statement made by the author on page 233 of Volume II. He states that "the technique of extirpating anorectal cancers and strictures is practically the same." To our minds, there should be an enormous difference between the method employed for excising a rectum which is the seat of non-malignant stricture and that adopted for extirpating the cancerous rectum. We note that the author is in favour of the

vaginal route for removing a cancerous growth of the rectum in women. He claims that by it an excellent exposure is obtained, but a glance at Fig 637 shows the necessity of dividing the bowel quite close to the margins of the growth. The author's method of performing the abdominoperineal operation is by no means a radical measure, because, according to Fig 642, the part of the pelvic mesocolon which contains the inferior mesenteric vessels—along the course of which the upward spread of cancer cells invariably takes place—is left behind.

Volume III deals with colitis, gastro-intestinal toxic disturbances, tuberculosis of the small and large intestine, constipation, and benign and malignant growths of the small and large intestine. These call for no comment, but there are excellent chapters on diverticulosis and the colostomies which are well worth reading.

The book is exceedingly well printed, and the illustrations are numerous and excellent. We strongly recommend it to those who wish to make themselves familiar with the author's personal technique in performing the operations of rectal surgery.

Diseases of the Rectum and Colon and their Surgical Treatment By J P LOCKHART-MUMFERY, FRCS Demy 8vo Pp 872 + 1, with 215 illustrations, and 5 in colour 1923 London Baillière, Tindall & Cox 25s net

THIS book is a revision of two separate works, *Diseases of the Rectum*, and *Diseases of the Colon*, which are combined into a single and handy volume. We congratulate the author upon having brought the work thoroughly up to date by incorporating recent work in several departments of the subject. The opening chapter gives an excellent account of the anatomy of the rectum and colon, though we doubt whether an anatomist would concur with the statement that the rectum starts slightly to the left of the middle line just below the bifurcation of the aorta. Even the older anatomists considered that the rectum was situated entirely within the cavity of the true pelvis. They held that the rectum was divisible into three parts, and described the first part as extending from the level of the left sacio iliac synchondrosis to the middle of the third piece of the sacrum. Modern anatomists, however, relegate the first part to the pelvic colon, and describe the rectum as commencing at the middle of the third sacral vertebra.

Chapter 2 deals with the physiology of the large bowel. An interesting account of the experiments carried out to determine the effect of the contents of the colon upon peristalsis is given, and the causation of acute dilatation of the colon and post-operative meteorism is fully discussed. We agree with the view that post-operative meteorism is invariably due to sepsis.

Much useful information is contained in the chapter dealing with examination and diagnosis. The uses of the sigmoidoscope are well described, and several valuable hints are given for guidance when this method of examination is resorted to. The author rightly insists that no force whatever should be used when the sigmoidoscope is being passed, and that, once the instrument has entered the rectum, it should be passed entirely by sight.

Chapter 5 treats of antiseptic technique in relation to operations upon the rectum. By most authorities it is assumed that, owing to the presence of the *Bacillus coli communis* and other bacteria, it is impossible to obtain aseptic conditions in the rectum. It is very gratifying, therefore, to learn that asepsis of the rectal mucosa can be obtained by spending a little time in washing out the rectum with a weak solution (one drachm to the pint) of lysol. Dr Wyard, pathologist to St Mark's Hospital, made several bacteriological tests to prove this. He took a series of swabs from the mucous membrane in cases of piles after the parts had been cleansed and just before the operation was begun. The results were in all cases negative.

Chapter 7 contains an account of that interesting condition megacolon or Hirschsprung's disease. The author remarks that no one has been able to offer any really satisfactory explanation of its etiology, and goes on to say that the resulting pathological condition points conclusively to something causing obstruction to the passage of faecal material along the affected portion of the colon, but fails entirely to reveal an anatomical cause for the obstruction.

Chapter 8 is devoted to the consideration of hæmorrhoids. We confess that we do not follow the author's reasoning when he says on page 157 that "the reason why we suffer from piles is because of the blood in this branch of the plexus having to go into the portal system." We agree that the so-called thrombotic pile is not due to thrombosis at all, but is produced by a local extravasation of blood from a ruptured peri-anal vein. A good account of the various operations that have been devised for the removal of internal piles is given. Preference is shown for the ligature operation as yielding the best results. Whitehead's operation is condemned, the author's principal reason for dislike of the method being that recurrence is frequent. In this connection he says that he has found recurrence to be more common after Whitehead's operation than after any other.

Chapter 10 deals with the subject of prolapse. Prolapse affecting the mucous coat of the bowel only is regarded as an earlier phase of a prolapse which involves the whole of the coats of the rectum. We do not subscribe to this view and regard them as two totally distinct affections. When discussing the pathology of prolapse, two degrees are described—namely, a first degree in which the mucous membrane covering the outside of the prolapse is continuous with the anal margin of the skin, and a second degree in which there is a definite sulcus between the prolapse and the anal margin (*Figs 68 and 69*). We would regard the latter as an example of intussusception of the rectum rather than as a degree of prolapse. When treatment is discussed we find mention of a third degree, but its characteristics are not described.

The succeeding five chapters deal with volvulus of the colon, adhesions and kinking of the colon, intussusception, enteroptosis, hernia, and intestinal stasis and chronic constipation. Inflammatory conditions of the rectal mucosa are discussed in the following three chapters, and an excellent account is given of the method of treatment known as cataphoresis. The treatment of ulcerative colitis is fully discussed. We agree that the best surgical procedure is appendicostomy followed by irrigation of the colon.

Chapter 19 contains a good and very clear account of diverticulitis, representing the present state of our knowledge of that curious disease. We agree with the opinion expressed that colostomy, followed at a later date by resection after all inflammatory phenomena have subsided, is the best treatment of the condition. Chapter 21 deals with the subject of abscess. Our conception of an abscess is that it is a localized collection of pus. We do not therefore follow the author's remark on p. 515 that he would not hesitate to cut into one of the abscesses before any pus had formed.

The subject of fistula in ano is considered in Chapter 23. In this, as in many books on the subject, all fistulae are regarded as belonging to a single type, of which there are several varieties. As a matter of fact, there are several types, each of which presents varieties. The literature upon fistula is particularly meagre, which no doubt accounts for the old classification still prevailing.

Chapter 30 and the three succeeding ones are devoted to malignant disease of the rectum and colon. A good and clear account of the manner in which cancer spreads from the rectum is given, and great importance is attached to accurate knowledge of the anatomy of the lymphatics through which that spread takes place. The chief path by which cancer cells spread from the rectum is along the lymphatics which accompany the inferior mesenteric artery and veins. Spread in this area invariably exists in the specimens that have been removed by operation, that is, in operable cases. It is not possible to remove this lymphatic area by an operation carried out from the perineum, because it is out of reach. Nevertheless, we find that the author prefers the perineal route when operating for cancer of the rectum, in fact he does an operation that is equivalent to removing the breast without clearing the axilla in a case of breast cancer. He reserves the radical or abdomino-perineal operation for advanced cases only, in defiance of the great principle in cancer surgery that the most radical operation for the earliest possible ease of cancer means the greatest immunity from recurrence.

We agree that when dealing with a carcinomatous growth of the colon drainage of the proximal portion of the colon—when obstruction exists—should always be carried out before any attempt is made to resect the diseased portion of the bowel.

The suggestion, however, that cæcostomy should be blindly performed in cases of obstruction without determining the nature or seat of the obstruction by exploratory laparotomy does not commend itself to our judgement.

The remaining chapters concern colostomy, the closure of fecal fistulae, and injuries to the rectum and colon, and they contain much useful information.

The book is well printed and illustrated. We consider it to be an excellent treatise, and recommend it to those who wish to acquire a sound knowledge of present-day surgery of the rectum and colon.

Diseases of the Male Organs of Generation By KENNETH M. WALKER, F.R.C.S.
Demy 8vo Pp 234 + vii Illustrated 1923 London Oxford Medical Publications
12s 6d net

THIS book forms a valuable addition to the Oxford Medical Publications and can safely be recommended to students and practitioners as containing a very concise and practical description of a most important subject. In several branches of the subject the author's name is well known, and his views thereon are very clearly expressed. In connection with chronic enlargement of the prostate, he is of opinion that the change is not adenomatous, but of the nature of a fibro-epithelial degeneration comparable with that which occurs in the breast, and the first two figures illustrate the histological resemblance of the two conditions. The treatment of prostatic enlargement is very clearly given, and the author rightly insists upon the importance of carrying out any preliminary investigation, such as estimation of the amount of residual urine or cystoscopy, in the patient's own house or in a nursing home, so that he may remain in bed.

In estimating the renal efficiency, the author makes use of the following the clinical picture, the quantity of urine and its specific gravity, the percentage of urea in the blood, and the urea concentration. The clinical picture is—wisely, we think—placed first on the list. As a rule the presence of over 2 oz. of residual urine is regarded as a strong argument in favour of operation. When the blood urea is above 80 mgm. per 100 c.c. and the urea concentration under 1.5 per cent, it is considered advisable to perform a preliminary suprapubic cystotomy.

The author's views as to the modes of infection in genital tuberculosis are well known, and the arguments are clearly expressed in support of his opinion that tuberculosis of the testicle, beginning usually in the tail of the epididymis, is the result of a descending infection from a focus in the prostate or vesicles by way of the lymphatics around the vas. In dealing with a malignant tumour of the testicle, the view is expressed that attempts to remove the retroperitoneal lymphatic area cannot be recommended, the testicle and the cord as high as the internal ring should be removed and intensive X-ray treatment adopted. Cautious reference is made to such subjects as the operative treatment of chronic prostatitis and vesiculitis, and the recent attempts to deal with testicular insufficiency. The last two chapters deal with the difficult subjects of sterility and sexual neuroses.

Venereal diseases have been intentionally omitted, and in connection with major surgical procedures the author has dealt more fully with the treatment of the patient before and after operation than with the details of the operation itself.

The book is very readable, and the illustrations are carefully selected, without the desire—too common at the present day—to make them as numerous as possible.

Guy's Hospital Reports Vol LXXIII (Vol III, Fourth Series), No 4 1923 London
Oxford Medical Publications Subscription £2 2s 0s Single Number 12s 6d net

EIGHTEEN separate articles are included in this issue, but only a few of them are of surgical interest. These include a resume of the operative treatment of exophthalmic goitre and the records of a few rare cases.



Thomas P Teale

THE BRITISH JOURNAL OF SURGERY

VOL. XI

APRIL, 1924

No. 44

EPONYMS

BY SIR D'ARCY POWER, KBE, LONDON

XII TEALE'S AMPUTATION

THE death of Mr Thomas Pridgin Teale last November, at Leeds reminds us that he was the son of the surgeon who invented the operation of amputation by a long and a short rectangular flap—a method which came into extensive use, and is, even now, more widely used than its merits deserve, for the conditions which it was designed to meet have long since vanished from surgery.

The first description of the operation was published by Messrs Churchill in a thin octavo volume in the year 1858, in which Mr Teale says, "In my early days of practice, upwards of thirty years ago, when fresh from the school of Lisfranc, I adopted the transfexion method by two lateral flaps. Charmed by the brilliancy of the operation, I expected it would prove equal to the utmost wishes of the surgeon. In the dissecting room it was certainly admirable, but when practised on the living it did not equal my expectations, and soon gave way to the circular method. At a later period, the example and strong recommendation of others led me to adopt the plan of transfexion with an anterior and a posterior flap. This proceeding was soon left off in favour of the circular incision which I continued to practise until the middle of the year 1855 when the mode of operating was adopted which it is now my object to describe.

"On reviewing my former practice and experience, if I were called upon to decide between the relative merits of the circular and transfexion methods, preference would be given to the former. My chief reasons for relinquishing these methods of operating are, the imperfect condition of the stump generally resulting from them and then great mortality."

How great this mortality was is shown in the tables given by Mr Teale of the results of 640 amputations of the thigh and leg for accident and disease performed in London and provincial hospitals from 1854 to 1857. In London there were 103 deaths in 317 amputations and in the provinces 102 deaths in 323 cases or a mortality of nearly one in three. But in addition to the mortality Mr Teale points out that the operations in use yielded unsatisfactory stumps. He says "in imputing generally *imperfection of stump* to the circular

and double-flap transfixion methods I shall perhaps be opposed by most surgeons who have amputated frequently. Each will be ready to say that he is in the habit of making excellent stumps, and indeed such was my own feeling in reference to these operations performed by myself. But when the subject is considered more closely, we may ask ourselves whether a stump is to be regarded perfect merely because it is of seemly form and not offensive to the sight. We ought further to enquire whether it is well adapted to locomotion by being able to bear a considerable portion of the weight of the body on its end. As a general rule it may be stated that the circular and transfixion stumps are not able to bear even the lightest pressure on their extremity.

"Being unwilling to rest this assertion on the personal experience of my colleagues and myself, I must appeal to the evidence which can be furnished by surgical mechanicians who have had extensive experience in the adaptation of artificial limbs." He thereupon quotes Mr. Heather Bigg, who stated that he hardly ever found the cicatrix after amputation of the limbs *'otherwise than adherent to the sawn end of the bone,'* and of Mr. Grossmith, who did not "remember any circular or transfixion stumps in which there was a soft, movable mass of tissues over the *sawn end of the bone*, and, as a general rule, he has found the cicatrix adherent to the bone. The cicatrix thus united has proved the most tender part of the stump." Mr. Thomas Eagland, of Leeds, said "that his experience was in perfect accordance with that of Mr. Grossmith and Mr. Bigg, as far as regards the stumps formed by the older methods of circular incision and transfixion."

To procure a more useful stump, therefore, and in the hope of somewhat diminishing the mortality of the operation, Mr. Teale "proposed to amputate by a long and short rectangular flap, the long flap, folding over the end of the bone, being formed of parts generally devoid of large blood-vessels and nerves, whilst these important structures are contained in the short flap."

"The size of the long flap is determined by the circumference of the limb at the place of amputation, its length and its breadth being each equal to half the circumference. The long flap is therefore a perfect square, and is long enough to fall easily over the end of the bone. In selecting the structures for its formation such parts must be taken as do not contain the larger blood-vessels and nerves. A flap so formed will be for the most part anterior in position as far as regards the general aspect of the body, but superior when the patient is in the recumbent posture, as during the after-treatment. The short flap containing the chief vessels and nerves is in length one fourth of the other. The flaps being formed, the bone sawn, and the arteries tied, the long flap is folded over the end of the bone, each of its free angles is then fixed by suture to the corresponding free angle of the short flap. One or two more sutures complete the transverse line of union of the flaps."

"After the patient has been carried to bed the stump is laid on a pillow over which a large sheet of gutta-percha tissue has been spread. *No dressing whatever* is required in the early part of the treatment. A light piece of linen or gauze is thrown loosely over the stump and pillow, and these are protected from the pressure of the bed-clothes by a wire-work guard. To relieve tension the lateral sutures may be removed on the following day, but those of the

transverse line may be allowed to remain until they are cast off, or appear no longer needed on account of the consolidated union of the parts. When the sutures of the transverse line have lost their hold, if the flaps should gape a strip or two of adhesive plaster may be applied. Simplicity in the treatment is thus secured, as well as disturbance of the stump avoided.

"To carry out these objects completely, the attendants must be strictly enjoined not to lift the stump from the pillow without the authority of the surgeon. As there are no dressings to be soiled, and therefore to require removal, the stump generally need not be raised from the pillow for many days or even for two or three weeks. When there is a discharge of matter, the nurse must remove it frequently by a soft sponge from the subjacent gutta-serena, without lifting the stump."

When Mr Teale wrote the operation had been performed fifty-six times in Leeds: thirteen times by Mr Samuel Smith, twenty-seven times by Mr Teale, fourteen times by Mr Samuel Hey, once by Mr C G Wheelhouse and once by Mr T Pridgin Teale junior. Seven of the fifty-six patients died. Looking back with our present knowledge, it is clear that so excellent a result was due to the simple dressing and after-treatment rather than to any great merit in the formation of the flaps. Mr Teale found on following up the cases that nine of the patients were wearing artificial limbs, all of whom were able to pursue their ordinary avocations for the full period of a day's work. "One young man can walk ten miles a day and a youth who bore the entire weight on the end of the stump, walked in this condition on one day thirty miles."

Mr Thomas Pridgin Teale was born at Leeds in 1801, the son of Thomas Teale who was a successful practitioner in the town. He was educated at the United Borough Hospitals and was admitted a Member of the Royal College of Surgeons in 1823. He then went home again, helped his father in the practice and was elected Surgeon to the Leeds Public Dispensary in 1824, a position he continued to hold until 1833, when he was appointed surgeon to the Leeds General Infirmary, a post he resigned in 1864, when he was complimented by being elected an Honorary Surgeon.

He soon acquired a large operating practice in spite of the fact that he had lost the sight of one eye as the result of an explosion whilst he was making chemical experiments as a boy. He excelled in lithotomy, lithotrity, operations for strangulated hernia, for removal of tumours of the jaw and in 'plastic surgery'. To the end of his life he was active in inquiry and research, and he used to test the new plans of treatment put forward by the various schools in Europe and America. He lectured for twenty-five years in the Leeds School of Medicine chiefly on anatomy and physiology, and added many pathological preparations to the museum. In 1843 he was elected to the newly established order of Fellows at the Royal College of Surgeons of England and in 1858 he was selected as a member by the Crown upon the General Medical Council. In 1862 he became a Fellow of the Royal Society and in 1867 the degree of M.D. was conferred upon him *honoris causa* by Trinity College Dublin.

Teale had many interests outside his profession. He was one of the earliest and most active members of the Leeds Philosophical and Literary

Society, of which he served as President on two occasions. In 1838 he was elected honorary Curator in Zoology, and he contributed two important and elaborate papers, the one on "The Natural History of the genus *Actinia*" the other on "*Alcyonella Stagnorum* a Freshwater Zoophyte inhabiting Ponds near Leeds". His last zoological contribution to the Society was in 1839, when he read a paper "On the *Cephalopoda*", but in 1852 and 1853 he contributed valuable geological memoirs, "On the Fossil Fishes of the Yorkshire Coal-field", and "On the Aire Valley and its Organic Remains". His sole relaxation lay in salmon fishing. He died on December 31, 1867, having maintained and even enhanced the surgical reputation of the Leeds School of Medicine founded by Hey and Smith.

The portrait is copied from an engraving kindly lent by Sir Berkeley Moynihan, Bt., K.C.M.G.

INJURIES TO THE KIDNEY AND URETER.

By HAMILTON BAILEY, LONDON

INTRODUCTION

INJURIES to the kidney, in regard to the collection of cases upon which to base a paper fall sharply into two groups (1) *Those in which the injury is mainly, if not entirely, confined to the kidney*, and (2) *Those in which the injured kidney is but one of two or more severe internal injuries*

Between 1902 and 1923, one hundred and thirty-five cases of injury to the kidney were admitted into the London Hospital of these, twenty-seven belong to Group 2

Group 2—Multiple internal injuries in which the injury to the kidney is but an incident have but little bearing upon the clinical side of the subject in hand Most of the patients in this group were admitted to hospital in a moribund condition, and all died shortly after admission In the majority the shock was so profound as to preclude all possibility, or even necessity of making a precise diagnosis and a ruptured liver, spleen, or intestine fractured pelvis, and lacerated lung, in addition to a ruptured kidney, was found at necropsy In four of the 27 cases a laparotomy was performed for a hæmoperitoneum, in one a ruptured liver was packed, and in three a lacerated spleen was extirpated

In former communications^{8, 12, 20} upon this subject it has been customary to discuss and include in the series of cases, "ruptured kidney complicated by ruptured liver, or spleen, etc" Observing that the general condition permitted an exploratory operation in only four instances, and that in each of these a ruptured intra-peritoneal viscus alone received attention, it would appear reasonable to state that a ruptured intra-peritoneal viscus should not, except in rare instances be designated as a complication of a ruptured kidney but rather vice versa

The present paper is based upon the 108 cases belonging to Group 1, admitted to the London Hospital between 1902 and 1923 In addition, cases of injury to the kidney between the years 1893 and 1902 have been collected from the same source and consulted, but not analysed in detail

STATISTICAL DETAILS

Relation to Peritoneum—In all the 108 cases the rupture was extra-peritoneal

The Side Injured—The side affected was left kidney, 50, right kidney 39 side not stated 19

In series that include post-mortem evidence (multiple injuries)^{8, 12, 20} the right kidney is most frequently damaged In the present series the reverse proved to be the case

Incidence—Females were much less frequently affected than males males 99 females 9

The most important and obvious cause of this very great discrepancy is that males, by reason of their work, are more liable to injury Contributory factors are the wearing of corsets and the greater renal mobility in females

Mortality—Number of cases treated expectantly, 82, number of cases treated by operation 26 The only death was due to chloroform poisoning

The gross mortality of these accidents has been reduced considerably during the past thirty years, principally owing to (1) The prevention of infection (cystitis pyelonephritis), (2) Operative intervention for the arrest of hæmorrhage in selected cases The first instance of nephrectomy for a rupture was in 1883 The operation was performed by Henry Rawdon¹¹ at the Infirmary for Children Liverpool The patient died twenty-three days after the operation, of cystitis and pyelonephritis It was some years after the pioneer work of Rawdon that the limitations of expectant treatment (brilliantly successful as this treatment is in the majority of cases) were realized

Analysis of Operations in this Series—

Nephrectomy was performed 21 times, partial nephrectomy once, suture twice, tamponade once, drainage of infected perirenal hæmatoma once, total 26

Morbid Anatomy—Rupture usually occurs along a line radiating from the renal pelvis The line of cleavage follows the direction of the uriniferous tubules (*Fig 332*), as Keen⁹ pointed out

Although it is stated that the anterior surface of the kidney is the most frequently ruptured it was found in this series that the posterior surface was equally liable to be the main site of laceration In 25 consecutive cases requiring exploratory nephrotomy for injury, 6 had the lower pole (*Fig 333*) and 1 had the upper pole completely severed The renal pelvis may alone be torn, as

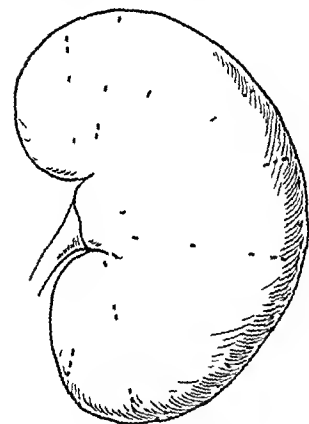


FIG 332.—Diagram of kidney to show usual lines of rupture

occurred in 2 cases in this series Post-mortem evidence in cases of lacerated kidney showed that the adrenal body is frequently injured This undoubtedly accounts in a large measure for the profound shock that sometimes accompanies kidney injuries Very occasionally the renal pedicle is completely torn across When this is the case, other organs are usually lacerated also

Anæmic infarction due to rupture of one of the radicles of the renal artery sometimes occurs The infarct in the lower pole of the specimen illustrated (*Fig 334*) may have been due to a tear of an aberrant renal vessel, for after the renal pedicle was ligatured and the kidney removed, an artery in the lower part of the wound had to be secured separately Mr Gilling Ball¹² recently demonstrated that infarction and necrosis in the kidney may follow an operation for division of abnormal renal vessels

The Nature of the Violence—It is stated in leading text-books that the usual accident which results in injury to the kidney is a crush (e.g. between buffers) As far as the practice in the East End of London is concerned this

type of accident is rarely the cause of the injury in question. There is but a single example of a crushing accident in the accepted meaning of the term. This occurred between a bullock and a slaughtering-block.

In five cases only was the blow definitely applied to the anterior belly wall. In over 80 per cent of the cases the violence is stated to have been applied on the posterior or lateral aspect of the trunk.

There is but one case in all the world's literature of a ruptured kidney occurring as a birth accident.⁵ Spontaneous²⁰ rupture in acute parenchymatous nephritis has been reported.



FIG. 333.—Ruptured kidney—run over accident.



FIG. 334.—Ruptured kidney following a fall from a horse—arterial infarction of lower pole.

Kuster's¹¹ experimental work on animals and on the cadaver led him to believe that rupture from direct violence was due to an increased intranephric hydrostatic pressure at the moment of impact. The same authority came to the conclusion that when the kidney was damaged by indirect violence the injury was caused by an impact of the kidney against the upper lumbar transverse processes on the 12th rib. This work was done by Kuster thirty years ago and apparently his experiments have never been repeated, nor his theories challenged.

Dr. Henry Morris¹² believed that a fractured 12th rib in some instances was the direct cause of the laceration.

The type of injury in the majority of cases in this series falls sharply into certain categories, viz —

1 Falls on the back or side from a raised position to the ground	40
Falls from a height on to feet or buttocks (indirect violence)	3
Falls on the level (in both these cases the kidney was hydro-nephrotic)	2
2 Kicked by horse (back or side)	— 45
Kicked 'on' 'kneed' (mostly football accidents)	17
	9
3 Run over	— 26
4 Glancing blows from passing vehicles	10
5 Hit in back by falling objects (usually when stooping)	6
6 External wounds (stabs)	6
7 Other accidents	3
	12
	—
	108

Contrary to expectation in an age of mechanical transport (1902-23) the largest individual incidence was a 'kick from a horse'

It is of considerable significance that in 6 of the 26 cases operated upon, the ruptured kidney was found to be also diseased. Brief notes of the operative findings in these cases are as follows —

Case 1—Deep transverse rupture of the kidney. One large calculus lying free in the perinephric blood clot, four smaller calculi in kidney substance.

Case 2—Tear of the renal pelvis. Hydronephrosis. Ureter much thickened.

Case 3—Tear of renal pelvis 2 inches long. Kidney hydronephrotic.

Case 4—Hæmorrhage into and around large (? congenital) hydronephrosis. Ureter dilated. Kidney parenchyma very thinned out.

Case 5—Hæmorrhage into advanced hydronephrotic kidney. Kidney contained one stone.

Case 6—Deep transverse rupture of kidney, full of cysts. Histological report congenital cystic kidney.

In two of the above cases the injury was comparatively slight (falls to the ground while walking in the street).

CLINICAL FEATURES

For purposes of instruction, injuries to the kidney are often divided into two great classes (1) *Slight*, which embrace those cases that can be treated expectantly, and (2) *Severe* cases which require operation in order to prevent death from hæmorrhage.

Admittedly this classification is impressive, and serves to emphasize certain valuable points. Nevertheless, at times it is somewhat ambiguous as the following case illustrates —

Case 1—Male, age 18, was kicked in the right loin by a horse.

ON ADMISSION—Pulse 86, temperature 97.5°. There was no sign of external injury or swelling in the loin. Considerable tenderness of right side of abdomen was present, also rigidity of upper right rectus. The urine contained blood. Slight hæmaturia continued for five days. During this time the rigidity persisted and the patient complained of pain in right side. Pulse remained full and slow. Suddenly, at 1.30 p.m. on the sixth day, there was a torrential hæmaturia. The lad became collapsed. After morphia and posture had improved the general condition, a necrotic kidney was extirpated.

INJURIES TO THE KIDNEY AND URETER 613

Delayed severe haematuria occurred in two other cases on the third and fourth days respectively after accident.

It follows then that if this classification is to be retained a classification which should imply one embracing the following stipulations: (1) There are no general signs after an arbitrary period six one hour to allow recovery from shock. (2) There are no local signs. (3) The only feature which draws attention to the fact that the kidney has been damaged is a trace of blood in the urine.

On the Local Signs in 'Severe' Cases

The absence of superficial bruising counts for nothing—it was present in only a small proportion of the cases. The same may be said of the classical 'swelling in the loin' when the posterior aspect of the patient is inspected.

Of greater general utility as an early sign is a flattening of the normal contour on the affected side when viewed from the front, provided the patient is spine (Fig. 335).

A dullness of the percussion note lateral to the outer border of the rectus as compared with the opposite side is often a sign of value whilst rigidity

of the anterior abdominal wall on the affected side is constantly present in cases of ruptured kidney.

Haematuria.—This cardinal sign of damaged kidney may not make its first appearance until some hours after the accident. In quite a large proportion of cases the urine voided soon after the accident was clean. The second sample, however, showed blood and urine intimately mixed.

Exceptionally the haematuria was not noticed for some days, thus, however occurred after slight injuries and it is highly

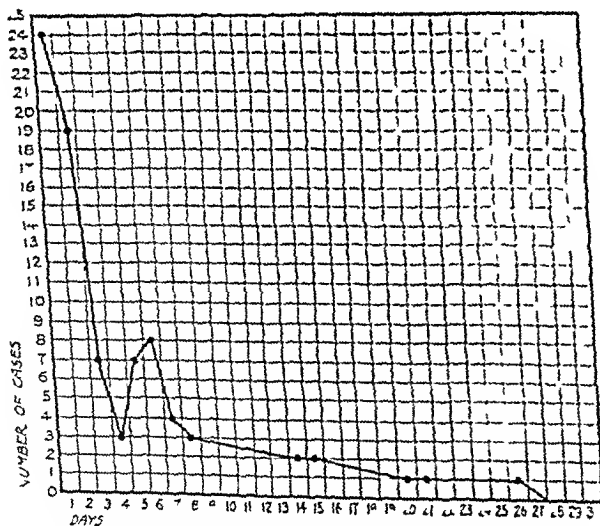


FIG. 336.—Graph showing the duration of haematuria in cases treated expectantly.

probable that the blood escaped notice in the earlier stages.

Those cases treated expectantly in which the macroscopical evidence of blood in the urine was recorded have formed the basis of the above graphic representation (Fig. 336).

It will thus be seen that, in the vast majority of cases, the hæmaturia ceased by the third day after the accident

Clot Colic—Two different clinical conditions are included under this heading—

1 *Ureteric colic* This is not very common, and when seen usually occurs within forty-eight hours of the accident. The passage of clots down the ureter give rise to pain radiating from loin to groin.

2 *Bladder colic* is a much more frequent complication. It occurs generally between the third and fifth day. The pain is considerable and referred to the glans penis.

The passage of clots does not necessarily produce colic. In two cases large quantities of clots were passed without any inconvenience.

Severe Delayed Hæmaturia—A sudden profuse hæmaturia may occur (usually between the third and fifth day) in a patient who appeared up to that time, to be progressing favourably. Three such cases, one of which has been cited, occurred in this series. The determining factor is probably some movement on the part of the patient which dislodges a clot into the renal pelvis.

Under the title *hæmaturia tardive*, Tuffier²⁰ describes the passage of large quantities of dark, altered blood occurring several days after the accident. Yarrow²³ has demonstrated hæmatoporphyrin crystals in the urine of a patient convalescent from a renal injury. In the most recent case of delayed hæmaturia in this series, the large secondary hæmorrhage was heralded by the passage of some 8 oz. of very dark urine.

In 1884, H. A. Reeves,¹⁸ surgeon to the London Hospital, recorded a case of severe delayed hæmaturia in a boy. The secondary hæmorrhage occurred on the tenth day after the accident, and was treated by subcutaneous injections of sclerotic acid. Death resulted, and the necropsy revealed a lacerated right kidney and a traumatic aneurysm of the renal artery. The latter is one of the first instances of this rare condition to be published.

Residual Hæmaturia—This may be the cause of some anxiety after nephrectomy has been performed for ruptured kidney. In spite of the fact that a damaged kidney has been removed, blood-stained urine continues to be passed. In such instances, one might well wonder whether the remaining kidney is injured also. The explanation is, that urine becomes stained by washing over clots that are present in the bladder. Blood-stained urine continued to be passed for from three to ten days in 20 per cent of those patients in this series in which nephrectomy had been performed. Doubtless residual hæmaturia plays a part—how much it is difficult to estimate—in very many cases of prolonged hæmaturia following renal injuries.

Retention of Urine—Acute retention occurring a few hours after the accident was present in 8 per cent of the cases. In these cases there was no evidence that the condition was due to blood-clot. Retention of urine occurring soon after the accident is probably reflex in nature.

True clot-retention occurred in a few instances but in these the retention commenced about the third or fourth day after the accident.

Oliguria, Anuria—Reflex oliguria is the rule after even a moderately

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severe injury to the kidney. Complete rupture of the ureter in connection the following case (which is not included in the series).

Case 2. Male, age 21, railway man. Admitted to hospital on Oct. 28, 1921. Had been crushed between buffer two hours before admission.

On Admission. There were pain and bruising in the left loin. Temperature 97°. General abdominal rigidity. Urine passed. After treatment had been instituted, general abdominal rigidity subsided, vomiting slight rise in pulse rate.

Operation. Laparotomy showed only sub-peritoneal haemorrhage in the left loin. Abdomen closed.

Next day the patient passed no urine. The following day he was catheterized and only 2 oz. of urine secured which contained altered blood. The following day complete anuria persisted in spite of catheters. Frequent vomiting. Death. At the necropsy there was shown to be a laceration in the parenchyma of the left kidney and the capsule was intact. The right kidney and ureter were entirely intact.

Rupture of a horse shoe kidney which terminated fatally from suppuration of urine has been reported.

Meteorism. In many cases of severe renal injury abdominal distention is seen and may give rise to difficulty in precise diagnosis. Theoretically, it might be reasonably conjectured that early and obvious sign of a severely damaged kidney would mask an intra-peritoneal complication such as a ruptured intestine and if this were so a ruptured kidney might be explored and dealt with effectively via the lumbar route whilst an (additional) intra-peritoneal complication was unavoidably overlooked. Between 1893 and 1923 no such case occurred at the London Hospital from which the comfortable conclusion can be drawn that in a given case of severe abdominal injury if the patient rallies from the shock and the signs are definite enough to indicate that the kidney has been severely damaged, subsequent meteorism does not as a rule imply a dual lesion and the case can continue to be treated expectantly as far as the peritoneum and its contents are concerned.

De Quervain¹ suggested that abdominal distention following a renal injury was due to interference with the blood-supply of that portion of the colon overlying the kidney. The records of the London Hospital support this view. Two cases of abdominal injury characterized by haematuria and considerable meteorism were explored through a laparotomy wound. In both bruising of colon, as shown by subserosal punctiform haemorrhages, was seen.

Urinary Infection.—Cystitis or pyelonephritis following injuries to the kidney is not now the rule. It occurred in only 7 per cent of the cases in this series and in no case did it prove fatal. In looking over an earlier series (1893-1902) of similar injuries one is struck with the frequency in which intermittent pyrexia and pyuria followed these accidents. Sir Henry Morris¹¹ in 1888 found that in 67 deaths resulting from renal injury 27 were due to sepsis. The improvement doubtless has been brought about by the routine employment of urinary antiseptics in these cases.

Perirenal Extravasation of Urine.—In tears of the renal parenchyma contrary to what might perhaps be expected, perirenal extravasation of urine rarely occurs. Of the two million¹ numerous tubules which constitute the renal parenchyma, comparatively few are directly implicated in any individual

tear Especially is this the case if the tear follows, as it usually does, the long axis* of the tubules But this alone will not explain the infrequency of urinary extravasation in parenchymal renal injuries It must be taken for granted that if any part of a uriniferous tubule is divided, the whole mechanism of that individual glomerulus and tubule ceases to function

Perineal extravasation of urine occurs principally in (1) Tears of the renal pelvis, (2) Ruptured ureter (which is most frequently a tear at the pelvo-ureteric junction), (3) Ruptured hydronephrosis

A medical student, age 24, was admitted to the London Hospital in 1908 The history was that he had been kicked at football in the left loin fourteen months previously in New Zealand After the accident, hæmaturia persisted for five days During this time a lump appeared in the left side This was aspirated and one pint of clear urine withdrawn After one month in bed he came to England to study He was quite well until two days before admission When examined there was a large lump in the left loin After four days' rest in bed a large quantity of urine was passed and the swelling disappeared Since 1908 he has played in international football and has served in the Army He still has periodic attacks of renal colic, which generally occur after a larger amount of fluid than usual has been consumed

This appears to be a case of rupture at the pelvo-ureteric junction Cicatricial stenosis at the site of the injury is the cause of the intermittent hydronephrosis

Perinephric Hæmatoma—This is frequently met with in cases of renal injuries The hæmatoma sometimes caused a bulging in the loin but this was somewhat exceptional, more frequently it tracked retroperitoneally to the iliac fossa One case of perineal hæmatoma (complicated with other internal injuries) seen at necropsy, and two cases viewed through a laparotomy wound were observed to infiltrate and push forward the mesentery It is stated that the hæmatoma may follow the course of the spermatic vessels, and after a few days ecchymoses appear in the skin of the scrotum, and round about the external abdominal ring Concerning this phenomenon (which has not been noted in any of the cases of this series), Sir Henry Morris¹² pointed out that most of the cases in which it had been observed were complicated by a fractured pelvis Not unnaturally, therefore, some scepticism exists as to the relationship of the perineal hæmatoma and this remote bruising Secondary infection occurring in these hæmatomata proved to be most exceptional Of thirteen cases of perineal hæmatoma large enough to be specially mentioned in the notes, only one became infected, the remainder, all treated expectantly, resolved

The possibility of these collections of blood being the cause of the perinephric abscess, in the general meaning of the term, is an interesting hypothesis Twenty consecutive cases of perinephric abscesses were therefore reviewed in the hope of establishing some connection between the two conditions There appears, however, but little to justify a co-relation A history of injury was obtainable in only 5 per cent and if one takes into consideration

* This should be the best line for incising the kidney in nephrolithotomy—the one least likely to give urinary fistula

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the readiness with which a hospital patient will attribute his accident to the number of perimphic abscesses which he has suffered from must be exceedingly small. Furthermore perimphic abscesses point in the true fossa. Perimphic hematomata frequently do so.

As in hematomata of other situation, very often the urine of blood becomes encysted and in process of time the cysts burst. Such a case is published in the *St. Thomas Hospital Reports* and quoted by Macleod. The encysted hematoma was removed in the belief that it was a sarcoma.

MANAGEMENT AND TREATMENT OF RENAL INJURIES.

SEVERE INJURIES. Even when there are no general and local signs, all cases of hematoma following an accident should be put to bed and kept there until one week after all microscopic evidence of blood in the urine has disappeared. A urinary antiseptic is administered to prevent the superinfection of infection.

SLIGHT INJURIES. If on preliminary examination the case gives rise to the slightest anxiety the pulse rate should be recorded hourly. If this measure has been deemed advisable in the first instance then the frequent pulse reading should be continued for a longer period than the patient's general condition seems to justify for as has been shown signs of extensive laceration may be considerably delayed.

General Rest.—Once a precise diagnosis has been made morphine is administered and repeated as necessary.

Methods of Promoting Local Rest.

- 1 *Shaping the affected side* with adhesive plaster is an effective method of ensuring rest and is recommended by several authorities. Nevertheless its disadvantages are formidable—namely the local signs are hidden beneath the splint and increasing rigidity in local swelling cannot be observed.
- 2 *Rest between sand-bags.* A cloth having been laid across the abdomen sand-bags are placed on either side of the patient. This effectively prevents moving, and allows examination of the region.
- 3 *An ice-bag* is a valuable placebo. Methods 2 and 3 can be combined with advantage.

In all cases the urine should be saved and placed in glasses bearing a label indicating the time of voiding. It is then possible to compare one sample of urine with a later specimen and thus to estimate whether the external bleeding is progressive or not. In comparing two samples—especially in an artificial light—it is often helpful to dip a strip of white blotting-paper into each specimen after stirring. For purposes of comparison the concentration of blood in the urine is more readily seen in the absorbent paper. The presence of clots in one sample would of course vitiate the result.

The Diagnosis was Doubtful, and an Exploratory Laparotomy has been Performed, and a (retroperitoneal) Ruptured Kidney is found.—
Two methods are available for dealing with the kidney. (1) To sew up

the laparotomy wound, turn the patient over and make a lumbar incision (2) To remove (or rarely to suture) the kidney via the abdominal route

There are very great disadvantages in the former method for instance, the abdominal wound is very hastily closed and hernia may result as occurred in one case of the series. The abdominal wound must be dressed, the patient turned, the lumbar skin sterilized, towels adjusted and so on—all of which are time-consuming. Even then it is usually found that the position of the patient leaves much to be desired. Finesse of adjustment cannot be obtained as in the case of a 'set' lumbar operation.

It would appear that in these cases the second method is the one of election. The coils of intestine are packed off carefully. If exposure of the renal area is inadequate, the laparotomy wound should be turned into a Rutherford Morrison³ kidney incision by a transverse incision outwards. The peritoneum is then divided on the outer side of the colon and the colon and its mesentery are mobilized medially after blood-clot has been sponged away. The renal pedicle is secured and the kidney removed.

The lateral extremity of the transverse wound is used for drainage which is necessary in many cases.

II The Diagnosis of Ruptured Kidney has been made —

Indications for Exploration (via the lumbar route) (1) The immediate hæmorrhage is severe enough to endanger the patient's life, (2) The hourly pulse-reading is steadily rising especially in spite of morphia, (3) Severe secondary hæmaturia (blood transfusion after the pedicle has been secured is necessary in certain cases), (4) Continued moderate hæmaturia over many days—and consequent anæmia.

In a patient whose condition gives rise to no immediate anxiety but the hæmaturia persists in spite of general and local rest, or other signs make the exact extent of the injury doubtful, Friedman has suggested pyeloradiography to ascertain the site and severity of the lesion. Whilst theoretically, this would appear to be a measure not entirely free from danger, in Friedman's hands it has given most illuminating results.

III The Advisability of Lumbar Exploration has been decided upon —

The Anæsthetic—Chloroform should be avoided in these patients. It has been shown that oliguria is the rule and cases of serious depression of renal function are unable readily to eliminate a poison. The only death in this series following an operation upon an injured kidney was shown at post-mortem to be a case of chloroform poisoning—by jaundice, and fatty degeneration of the liver and remaining kidney.

Determining the Presence of the other Kidney—While only one individual in 1500 has congenital absence of one kidney, it should be the rule in injuries to the kidney to ascertain the presence of a second organ on the non-affected side. It is rarely permissible to neglect this step. The methods available are (1) Palpation under anæsthesia—frequently unsatisfactory (2) Cystoscopy combined with injection of indigo carmine—time-consuming for the bladder has usually to be washed out before anything can be seen satisfactorily. This excellent method is not available in urgent cases of

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severe hemorrhage. (3) Deliberately opening the incision, exposing the portion of the lumbar incision and then abdominal incision, and the hole in the peritoneum is subsequently sutured.

Indications for Nephrectomy—(1) The renal pelvis is torn. (2) The kidney is lacerated in several places. (3) There is a large extension of the renal pelvis but the kidney has a short pedicle and cannot be completely delivered—it is impossible to suture a rent which cannot be completely closed. (4) There is an extensive rent in the renal pelvis (which cannot be sutured) or the meter is completely avulsed. (5) The injured kidney is hydropic, or otherwise severely diseased.

II. Every Effort should be made to Save the Damaged Kidney. *Contra Indications*—Operations upon the kidney which can be adopted in certain cases.

Tamponade—Kuster¹² considered this to be the best of all methods. He also thought that it might be used as a temporary measure prior to nephrectomy a few days later. Keen has shown that secondary nephrectomy after tamponade carries a high mortality. At the London Hospital in the final decade of the last century this was the method most generally adopted. The perineal space was stuffed with iodoform gauze. The results were on the whole good. Infection frequently occurred but most of the patients eventually recovered.

Partial Nephrectomy—Tuffier¹³ showed by his experiments that one third of the kidney could be resected and the remaining two thirds continue to function. Partial nephrectomy is especially applicable in those cases in which the lower pole alone is damaged.

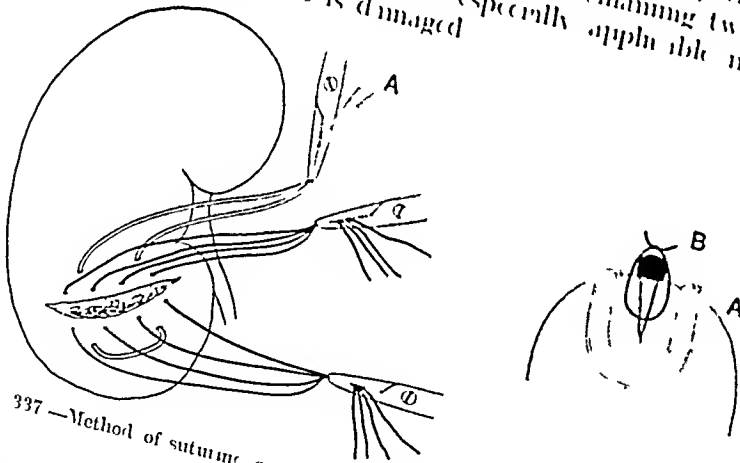


FIG 337—Method of suturing a rupture of the kidney. A Mattress suture which is tied last. B Piece of muscle

Suture—Of conservative measures this is the one which will be found most generally applicable. Eisendrath¹⁴ recommends that perineal fat should be used as a buffer under the sutures to prevent tearing out. Seeing that muscle is always available around a lumbal incision the following method (Fig 337) of suturing a rent of the parenchyma suggests itself. (1) The passage of a deep mattress suture—a round-bodied curved needle is used—the blunt end of the needle penetrating the renal substance

first The ends of the suture are left untied and secured with a Spencer Wells (2) Interrupted sutures are passed deeply, but nearer the edges of the laceration (3) A piece of muscle is placed over the rupture and the interrupted sutures are tied over it Finally, the mattress suture is tied

The advantages of this method would appear to be that the sutures do not cut out the muscle being rich in thrombocinase favours clotting, and the rent is plugged with Nature's own material

Simple Drainage of Perirenal Tissues only—This should be reserved for two types of renal injury (1) Perirenal extravasation, (2) Recent injury where a small tear of the renal pelvis is found which cannot, for some reason be sutured, and the parenchyma is undamaged A urinary fistula is likely to develop after simple drainage, but spontaneous closure eventually occurs in the majority of instances

Treatment of Infected Perirenal Hæmatoma—(Sheeren's method) If on abdominal palpation under the anæsthetic the swelling is found to be invading the iliac fossa (as it usually is), a gridiron incision is made as for appendicectomy When the peritoneum is reached, it is pushed medially, and the retroperitoneal tissue then opened up with the finger A tube is passed upwards towards the kidney The patient is nursed in a sitting position The infected extravasated blood is drained from its lowest point with minimal disturbance to the kidney, which, by the time the hæmatoma becomes infected is most probably in a stage of repair

RUPTURE OF THE URETER

There is only one instance in the records of the London Hospital during the past twenty years of an undoubted case of intraparietal rupture of the ureter This was seen at necropsy in association with other internal injuries The ureter was avulsed from the renal pelvis

From the clinical standpoint, a ruptured renal pelvis and a lesion of the ureter are indistinguishable (*see PERIRENAL EXTRAVASATION OF URINE*, p 615) Indeed, even when displayed to the light of day, a tear of the pelvo-ureteric junction is just as much a rupture of the renal pelvis as a lesion of the ureter A perusal of the literature convinces one that intraparietal rupture of the ureter is an exceedingly rare accident Certain of the reported cases are by no means convincing In indisputable instances the lesion has nearly always been found near the junction with the renal pelvis An exception to this rule was Dumitresco's case in which the lower third of the ureter was lacerated by a fragment of a fractured pelvis

Nash, during the course of an operation for perirenal extravasation of urine, saw a hole in the mid-ureter discharging jets of urine He assumed that the rent was due to an injury, although the patient (an adult male) denied an accident of any kind This interesting condition permits of another explanation, viz, ulceration around a ureteric calculus as occurred in Raymond Johnson's case There is no doubt that during the past fifty years pelvic operations* (notably hysterectomy) have accounted for the vast majority of ureteric injuries

* Preliminary passage of ureteric catheters would minimize this accident

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CONCLUSIONS

- 1 Of all the internal catastrophes a ruptured kidney treated under modern conditions offers the best prospect of a complete recovery
 - 2 In those unfortunates with a single kidney a severe injury of that organ is probably always fatal
 - 3 The low mortality of renal injuries in general is very largely due to a provision of nitrate whereby the metamorphosis was bilaterally represented
 - 4 Operative intervention for the arrest of hemorrhage which would otherwise rapidly prove fatal an appreciation of those signs which herald the failure of expectant treatment and the prevention of infection have reduced the mortality to a vanishing point
 - 5 If two or more of the viscera are severely injured the prognosis is almost as grave as it was fifty years ago Progress in these cases is impossible until more effective measures of combating shock have been devised
- I beg to record my thanks to the surgeons of the London Hospital in general, and to my chiefs in particular for many favours

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INTRAMEDULLARY CAPILLARY ANGEIOMA OF THE SHAFT OF THE HUMERUS, LEADING TO SPONTANEOUS FRACTURE: TREATED BY LOCAL RESECTION AND BONE-GRAFTING

By SIR HAMILTON BALLANCE, NORWICH

With a HISTOLOGICAL REPORT BY PROFESSOR S. G. SHATTOCK, LONDON

IN November, 1913 I was asked by Dr. C. H. W. Page, of North Walsham, to see a farmer, age 37, who gave the following history —

When he was 13 years of age his left elbow was crushed between buffers, and since that time he had never been able fully to straighten the joint, but with this exception the limb completely recovered. About a year before I first saw him he began to have pain in the upper part of the left arm, this pain increased and the arm gradually wasted and became weaker.

The patient was a big, muscular man, and, with the exception of the trouble in the arm, enjoyed good health. The most tender spot was at the upper and inner part of the arm, at the lower end of the insertion of the pectoralis major, where a distinct ridge could be felt, the pain started from this spot and passed down the limb and along the back of the forearm to the fingers. A jerk of the limb, such as might occur when the patient was driving, would cause a sudden pain to dart all along the arm and forearm. There was tenderness along the musculospiral nerve in the lower half of the arm, but there was no anaesthesia. There was wasting of the supra- and infraspinatus, the deltoid, the triceps, and the pectoral muscles, and some general wasting of the forearm, all these muscles, however, still reacted to faradism. The power to abduct the shoulder and to extend the elbow was much diminished, flexor power of the elbow was much greater than extensor. There was not much wasting of the thenar and hypothenar eminences and the grip was fair, the elbow-joint could not be extended beyond 140°.

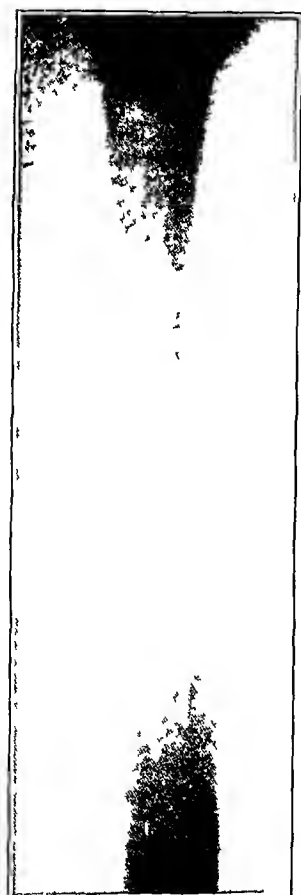


FIG. 338.—Skigram of patient taken two days before spontaneous fracture.

On Nov. 24, the patient was admitted to the Norfolk and Norwich

CAPILLARY ANGEIOMA OF THE HUMERUS 623

Hospital and radiographed (Fig 338) The plate shows that for a distance of about three inches absorption of practically the whole of the compact tissue of the shaft of the humerus had taken place the centre of the thinned portion being rather above the middle of the bone On Nov 26 the patient put his arm behind his back and although the movement was not a forced one the humerus suddenly snapped through the weakened portion

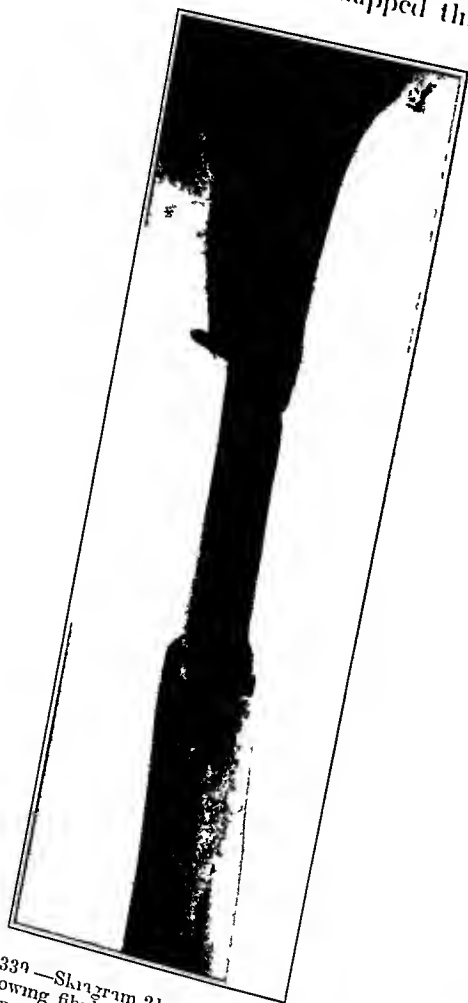


FIG 339—Skullgram 24 weeks after operation showing fibular graft in position fixed by screws

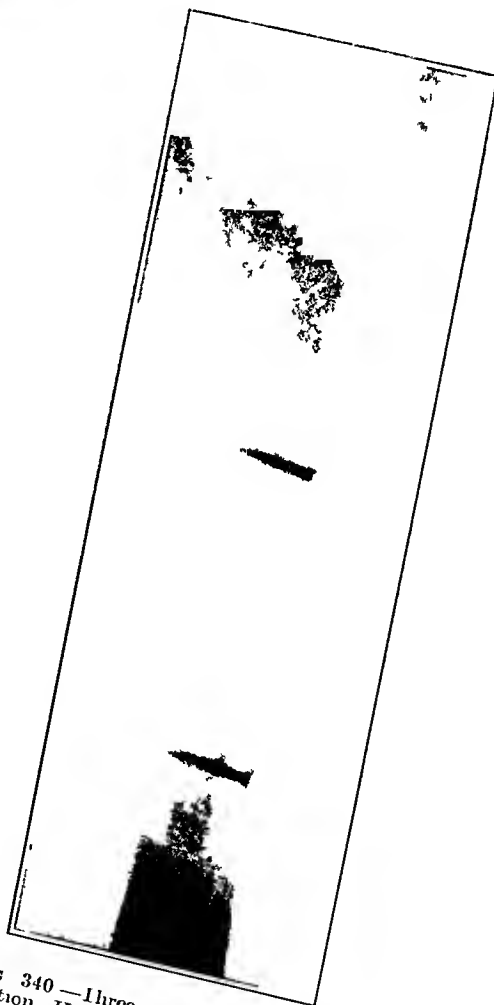


FIG 340—Three and a half months after operation Upper end of graft has come away from humerus and ends of humerus as well as graft are becoming absorbed

OPERATION—On Dec 5, the fracture was exposed by a long incision on the outer side of the arm The medulla of the fractured ends was noticed to be much redder than usual, and the outer surface of the thinned portion of bone pitted and irregular Bone was removed from the upper and lower fragments until the cut medullary surfaces appeared of a normal color An incision was made over the upper part of the left fibula, and four inches of the shaft was removed with its periosteum The medullary cavities in the cut

ends of the humerus were too small to receive the extremities of the fibular graft, so these were narrowed by sawing and were then forced into the ends of the humerus into which they fitted fairly firmly (*Fig 339*), but to keep the graft securely in position screws were inserted through the ends of the humerus and of the graft. The wounds healed by first intention, and the



FIG 341—Seven months after operation
The absorption has rapidly progressed



FIG 342—Skiaogram 8½ years after operation. Ends of graft have united with humerus but the graft greatly diminished in size has fractured at the screw holes. Upper screw has become eroded near its middle.

patient returned home with an internal rectangular splint on the limb and a poroplastic shoulder cap.

Three and a half months later a radiograph of the patient was again taken (*Fig 340*), when it was noticed that the upper end of the graft had

come away from the humerus, that both ends of the latter were being absorbed and that the graft was becoming irregular in outline.

Another skiagram seven months after the operation (*Fig. 341*) showed that the process of absorption in the ends of the humerus and in the graft had still further progressed. The war here intervened and the patient was not seen until some time after the armistice.

In March 1922, eight and a quarter years after the operation, the arm was once more X-rayed (*Fig. 342*). The graft had joined to the ends of the humerus, but had itself undergone extreme atrophy and had fractured at the points where the screws passed through it.



FIG. 343.—Front view showing atrophy of muscles of shoulder and arm.

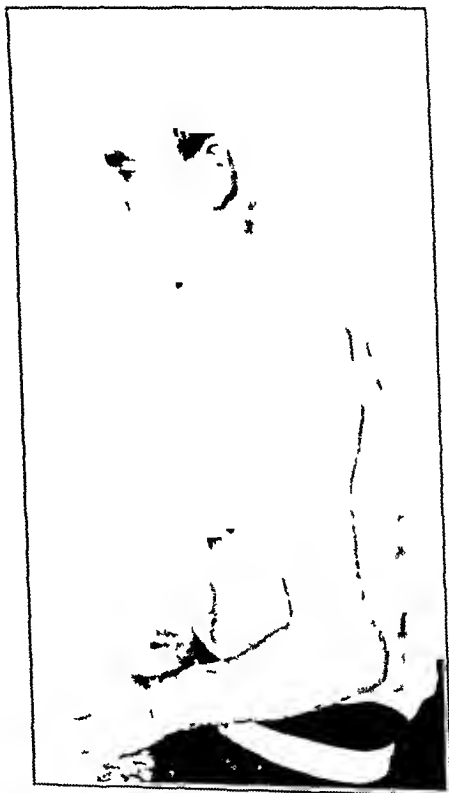


FIG. 344.—Side view.

The patient is now in the position of a man suffering from an ununited fracture of the humerus. He wears a leather ease round the arm to give rigidity to that portion of the limb, and by means of this support the forearm and the hand are quite useful to him. The photographs (*Figs. 343 and 344*) show the present condition of extreme atrophy of the muscles of the shoulder and arm.

Fig. 345 shows the condition, five months after operation, of the left leg, from which the fibular graft was taken. A recent skiagram shows much the same condition, and there has been no further progress made in the attempt

by Nature to bridge the gap in the fibula. The irregularity at the upper end of the lower fragment of the fibula is due to the fact that portions of bone, sawn off the ends of the graft to make them fit into the medullary cavity of the humerus, were replaced in the lower part of the wound in the leg. Skiagraphs of the right arm and right leg show the bones in these limbs to be quite normal in appearance.

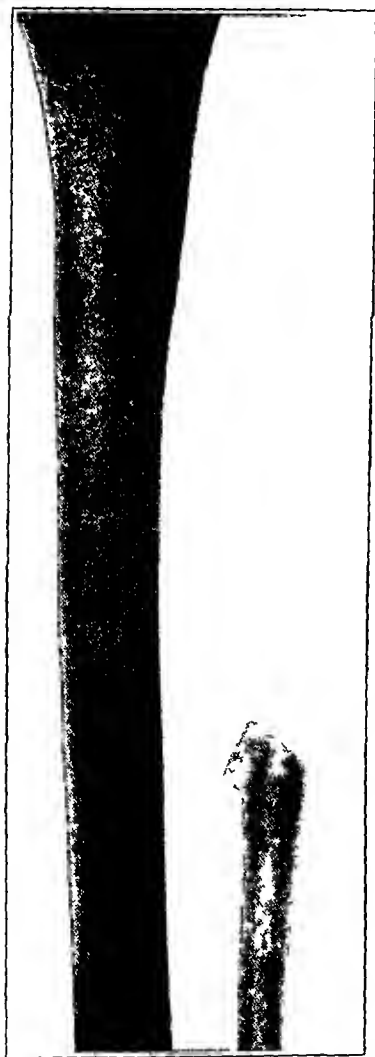


FIG. 345.—Condition of left leg five months after the fibular graft was removed.

HISTOLOGICAL REPORT BY

PROFESSOR S. G. SHATTOCK, F.R.S.

As studied in transverse sections of the shaft, the medulla is completely replaced by a capillary angioma, the vessels of which are abnormally large and are all distended with blood. The capillaries have a simple, flat celled, endothelial wall. The intervals between are occupied with normal connective tissue in which groups of fat cells are included, the only other elements present are inconsiderable and ill-defined collections of lymphocytes, distributed in the intervacular connective tissue (Fig. 346).

The wall of the shaft immediately around the growth is undergoing rarefaction, the capillaries with their associated connective tissue and scattered lymphocytes having made considerable gaps in the bone by the enlargement of the original spaces. The bone, where not destroyed, is of perfectly normal compact structure, well laminated, and furnished with normal corpuscles in normal numbers.

In certain of the capillaries the red cells have subsided before the coagulation of the blood has taken place after the excision, the coagulum being in consequence wholly or partly homogeneous, vacuolated and it may be dentate at the margin. It may be added that there is not the slightest indication of the neoplasm being symptomatic.

Professor Shattock adds, "There is no such specimen in the R.C.S. Museum, I have never myself seen such a thing, nor heard of any such having been observed in this country."

REMARKS

The extreme rarity of this case is one of the reasons for putting it on record. In spite of much consultation about it with surgical friends of mine, the true nature of the trouble was only revealed when Professor Shattock's

aid was sought, and I am deeply indebted to him for the interest shown and help given, and for the description he has written of the microscopical findings.

To Mr. Lawford Knaggs also I desire to express my thanks for much useful advice and for the references to the literature of the subject.

The blood tumours of bone described by Roughton and others are almost all examples of sarcomata of bone into which haemorrhage has occurred, and in these cases an important clinical sign has always been observed namely, expansion of the bone affected. Others however have been recorded by some of the older writers in which the development of new vessels in the part of the bone affected has been a marked feature and in which treatment that

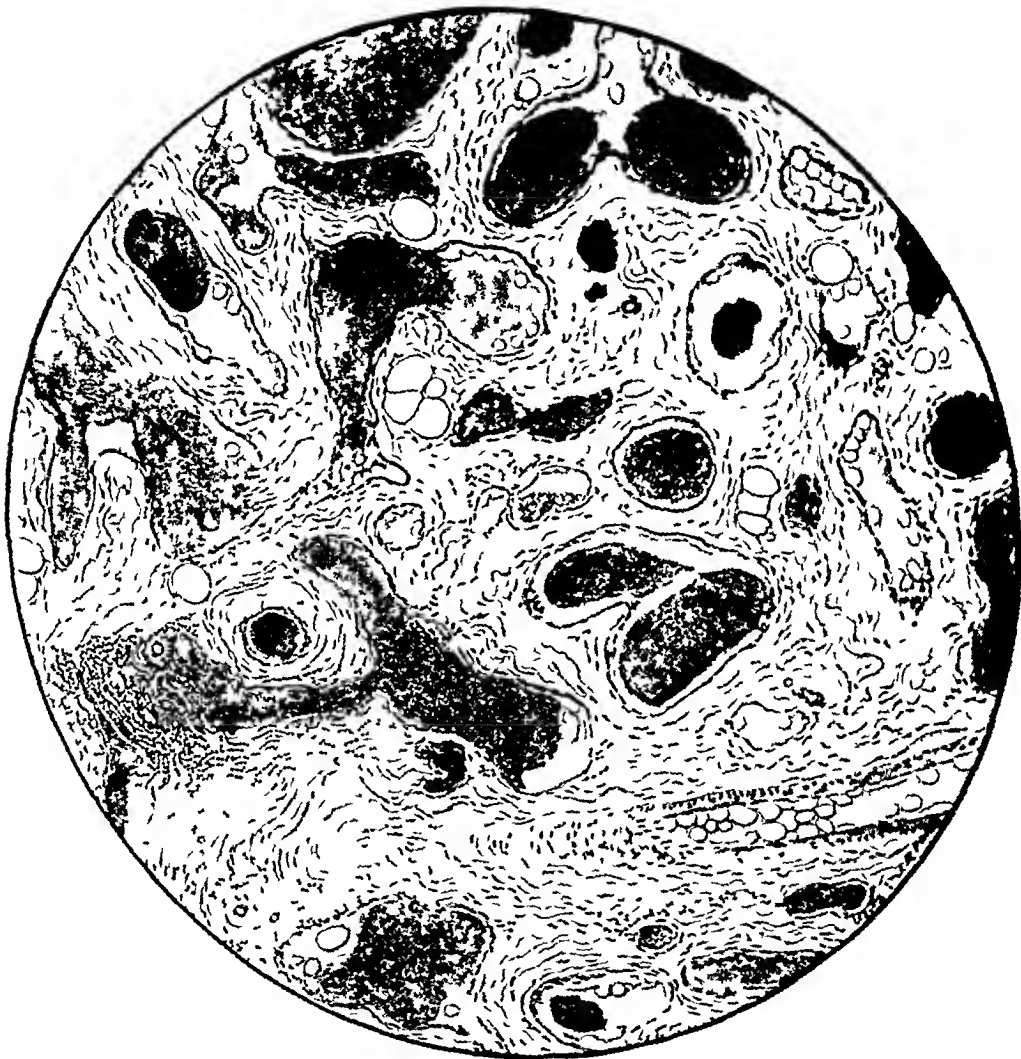


FIG 346.—Transverse section of thinned portion of shaft of humerus showing the plexus of dilated capillaries supported by connective tissue in which lie a few fat cells. In the lower part of the section are a normal arteriole and a group of lymphocytes (? obj.)

would have been quite inadequate if the tumour had been malignant has resulted in a cure.

The atrophy of the graft was very disappointing, and this may be due, as Mr Lawford Knaggs suggests, to its failure for so long a period to unite

with the ends of the humerus, but if the last skiagram of the arm be examined (*Fig 312*), it will be seen that the ends of the graft, although very much thinned, did eventually fuse with the humerus, and that fractures have occurred at the places where the screws passed through the graft. Some surgeons are much opposed to any fixation of a bone-graft by mechanical means to the bone to which it is expected to unite. It is not my experience that such fixation hinders the bony union desired later.

The question arises as to the best treatment of this patient in his present condition. Supposing a second attempt at grafting were made, including free removal of the ends of the humerus on each side of the atrophied first graft, is it to be expected that a second graft would meet with the same fate as the first? I do not think that this should necessarily occur, but for the present the patient prefers to continue as he is.

It may be mentioned that the man does not seem to suffer any disability from the removal of a good many inches of one fibula, although the gap between the ends has not been bridged by bone.

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AN EXTENSIVE MULTILOCULAR CYSTIC EPITHELIAL TUMOUR OF THE JAW

By C. A. MOORE, G. HADFIELD, and L. E. CLAREMONT BRISTOL

CASES of multilocular cystic epithelial tumour of the jaw or epithelial odontome although rare in the experience of an individual surgeon have been described for a century or more. For their pathological elucidation we are indebted mainly to Bland-Sutton, Eve, Malassez, Tomes, and others. They possess a triple interest—to the surgeon, the pathologist, and the dental surgeon.

To the surgeon, who has to deal with the question of operative removal the point arises as to how far they are to be regarded as malignant, and how radical his proposed operation should be. In earlier days they were regarded as definitely malignant, and operations for their removal were extensive and mutilating. Later, the trend of pathological opinion was in favour of their comparative benignity. More recently again Bland-Sutton has pointed out their close relation, in microscopic character and clinical behaviour, to carcinomata. They are to be regarded at any rate with considerable suspicion. While most pathologists follow Malassez in thinking that they arise in remnants of the enamel-organ, there are others who would label them as endotheliomata, or even epitheliomata, arising in the gum. An excellent summary of the present position was furnished by the report of the committee appointed by the British Dental Association in 1911.

Finally, to the dental surgeon, the problem presents itself of providing some artificial substitute for the jaw. If it cannot be expected to be of much service from a masticatory point of view, it will, at any rate, help to overcome the grave deformity resulting from the surgeon's unaided efforts.

CLINICAL HISTORY

The patient, a man of 40, was referred for surgical treatment by Mr. W. Holder Shipway, of Chepstow, from whom he had sought dental advice owing to repeated attacks of inflammatory swelling and pain in the enlarged jaw.

The patient stated that he first noticed a swelling inside the mouth, on the left side, twenty years before. For this, a minor operation was performed at Newport. He had no further trouble until six years before coming under notice, when the jaw began to swell again, and this had continued steadily ever since. The teeth had been extracted, or had fallen out, at intervals, and he is now entirely edentulous. The attacks of inflammatory swelling, mentioned above, had come on every few months during this time.

The appearance presented by the jaw is well shown in *Fig. 347*, and in *Figs. 348, 349*. The greater part of the mandible was expanded by an

irregular nodular swelling, most marked on the right side, and gradually tailing off towards the left where it ceased just in front of the angle. The nodular projections, by their appearance suggested cysts, while, in the case of the larger ones, the bone was so much thinned that elasticity on pressure, but no 'egg-shell' crackling, was readily felt. No teeth remained in either jaw so that intra-buccal sepsis was slight.



FIG. 347.—Fibrocystic lower jaw. The upper figure shows the jaw as removed (A) Mucous membrane of floor of mouth. The lower figure shows the upper half of the jaw in section (B) Muscle (C) Periosteum.

The affected portion of the jaw was removed through an incision below it, without serious difficulty or shock, the operation being immensely facilitated by skilful intra-buccal anaesthesia. The jaw was divided on the right side just below the notch, only a very narrow bridge of bone remaining to connect the condyle with the coronoid process. On the left side, the line of section passed just in front of the ascending ramus. No attempt was made at any temporary replacement of the jaw by an artificial substitute.

No shock followed, and local sepsis was remarkably slight. By the end of a fortnight all sepsis had subsided and rapid healing had taken place. The

field of operation was occupied by a dense mass of scar-tissue the contraction of which led to an unsightly hollow in the chin

At this stage the patient was kindly seen by Sir Frank Colver who advised the insertion of an epithelial inlay according to the method which proved



FIG 348—X ray appearance of tumour before removal

so successful at the Queen's Hospital, Sidcup, and of which details have been published by Kilner and Jackson¹

This suggestion was acted upon, three weeks after the first operation. The scar-tissue under the tongue was freely dissected away and the chin set



FIG 349—Tumour *in situ*

free, leaving a large cavity in the floor of the mouth. An impression of this cavity was taken in dental wax and covered with Thiersch grafts. The wax

cast was fixed in place by means of a splint which exerted the necessary pressure to keep the impression, with its covering of grafts, firmly in contact with the raw area in the floor of the mouth. Once more, grateful acknowledgement has to be made of the great help derived from intratracheal anaesthesia. The latter point was amply demonstrated when, at the close of the operation, the intratracheal catheter was removed. The large mass of dental wax in the floor of the mouth, and the firm pressure exerted by the splint, together with the fact that the tongue had again necessarily been set free from its attachments, so obstructed the breathing that tracheotomy was required before the patient left the table. The tube was removed next day and no further trouble with the respiration occurred.

In the Sidecup method of intra-buccal grafting, it is advised that the grafts be left undisturbed for ten days, and it was intended that this should be done here. At the end of exactly a week, however, the splint let the wax slip and become displaced. It was decided, as the lesser evil to remove the wax rather than make an attempt to manoeuvre it back into place with consequent risk to the vitality of the grafts. This course proved to be justified by the fact that the grafts had taken most completely not a trace of raw surface remaining. To one whose first experience this was of this method of intra-buccal grafting, the result was as surprising as it was gratifying. After the raw area was covered, practically no further contraction took place, and the work of fitting the new jaw could be proceeded with.

Looking back on the case, we are agreed that it would probably have made things easier if some sort of a temporary substitute for the jaw had been inserted at the first operation, before any contraction of the scar took place.

PATHOLOGICAL REPORT ON THE TUMOUR

By G. HADFIELD

Naked-eye Appearance—The specimen consists of the whole of the body and the lower part of the right ramus of the lower jaw, including the angle on the right side, on the left side the saw-cut made in removing the specimen passes just in front of the angle. The jaw is edentulous, grossly deformed and considerably distended by diffuse tumour-growth, which is located within the alveolar borders except where it has absorbed and pierced them, when it presents on the surface at several points as large low bosses, where it has either pushed the surrounding soft tissues in front of it and lies encapsulated by them, or is still enclosed in a thin parchment-like capsule of bone.

The amount of growth lying between the alveolar borders is so great that the thickness of the jaw is three to four times the normal.

The largest mass of growth lies in the position normally occupied by the incisor and canine teeth, and is covered by intact, smooth, thickened mucous membrane which is stretched over it. Its chief directions of growth have been upward and forward, pushing up and stretching the edentulous gum and absorbing the external and anterior surface of the bone on each side of the mental prominence. A fairly thick layer of bone still covers it on its lower and posterior surface. Another large mass of growth, continuous with the above, has almost entirely replaced the angle of the jaw on the right side,

whilst between these larger masses several smaller ones have absorbed the bone over smaller areas and project as smaller-sized bosses.

The growth is continuous between the individual masses and even where it has not absorbed the alveolar borders it has everywhere considerably separated them. A moderate amount of bone still remains on the left side where the deformity is much less.

On making a horizontal section through the specimen the diffuse infiltration and unequal distention of the alveolar borders by the tumour are very obvious.

For the most part the tumour tissue is firm, solid and opaque, is white in colour, looks homogeneous and resembles sarcomatous tissue, but in the centre of several of the larger masses of growth there are irregularly-circular, smooth-walled cystic cavities from $\frac{1}{2}$ to 2 cm. in diameter filled by clear mucinous fluid or opaque gummy yellowish material. In addition to these cysts some of the solid opaque parts of the tumour show in their centres areas of the same average size as the cysts, where the tissue is translucent and gelatinous-looking and apparently in the precystic stage.

Microscopic Characters—The growth consists of many solid branching tubules, flattened from side to side by mutual pressure, and varying considerably in size. They lie in a scanty fibrous matrix which is almost acellular. Most of the tubules are equally bifurcated, some show three or four equal-sized branches, but they do not appear to anastomose. Each tubule is covered on its external surface by a single compact layer of columnar epithelial cells, which have large, bluntly-spindle-shaped, vesicular nuclei.

The contents of the tubules vary. In all of them the outer part is filled by small stellate cells with rather deeply-staining round or ovoid nuclei, these cells have a scanty cytoplasm, which is continued into four to eight fine processes. The processes of neighbouring cells are fused, and give the tissue a characteristically reticulated appearance. Some tubules contain no other type of cell, and in these the reticulated cells are closely packed and small and their processes numerous. The majority of tubules, however, contain masses of squamous epithelium, arranged roughly as in the 'cell nests' of squamous-celled carcinoma. These cell masses have applied to their outer surface several layers of flattened reticulated cells, they all show a considerable degree of 'keratinization', loss of nuclear staining, and hyaline transformation. Where these masses are large, the tubule shows microscopic cyst-formation and in a moderate number of tubules this has progressed to complete transformation.



FIG. 350.—Two tubules showing cell reticulum and columnar cells lining them externally. The tubule on the right closely resembles a developing organ.

of the cellular contents into a series of discrete simple cysts with smooth acellular walls. The matrix is composed of well-developed fibrous tissue.

The tumour has all the characters of an epithelial odontome (adamantinoma), generally regarded as being derived from the parodontal epithelial debris. This latter tissue is found normally as cellular masses, or primitive tubules, deep in the tissue of the gum, and is derived from invaginations of the gingival epithelium which go to form the enamel-organ. It appears to be concerned with many inflammatory and neoplastic processes which take place in connection with the teeth.

The tumour described shows a small amount only of squamous epithelium, and histologically resembles an adenocarcinoma very closely. The columnar cells lining the tubules represent the enameloblasts of the primitive enamel organ, whilst the stellate cells of the central part of the tubules closely resemble its normal stellate reticulum (*Fig 350*).

Bland-Sutton, in his book on *Tumours* (1922), remarks that "a careful re-examination of a few of the specimens described as multilocular cystic epithelial tumours of the jaws, and a study of the description of others especially those occurring in individuals past middle life, indicate that many of these tumours are carcinomas. This view of the matter is confirmed by the fact that some of these cystic tumours of the jaw supposed to arise in belated rudiments, or vestiges of the enamel-organs, recur after removal. Moreover these tumours occur in individuals at or after mid-life, whereas if they arise in epithelial vestiges of the enamel-organ, they ought, theoretically, to be met with in the young. This is not the case."

THE DENTAL ASPECT

By I. E. CLARFMOND

At my initial examination of the case I assumed that it would be possible to replace the portion of the jaw that the surgeon proposed removing, by a hollow box of vulcanite carrying teeth and attached by springs to an ordinary full upper plate. Having never had occasion to design so large a restoration, I did not take into account the contraction of the soft tissues that would take place immediately after the removal of the tumour.

Four days after the first operation I took a plaster impression of the floor of the mouth. Great difficulty was experienced in obtaining a good impression of the upper jaw, partly owing to the extreme tenderness of the stumps of the vertical ramus, but more particularly to the fact that these stumps were pulled inwards towards the middle line by the unopposed pterygoid muscles. Plaster was found to be impossible in the upper jaw. A temporary apparatus was made in vulcanite without any teeth on it, the lower solid vulcanite block being attached to an edentulous upper vulcanite plate by a locking bolt on each side. When in place in the mouth with the bolts locked, the mouth was kept fixed in the half-open position. At the time I felt that a temporary apparatus of this nature would keep the soft parts well moulded during the process of healing.

In a very short time, it was obvious that the large amount of cicatricial tissue forming in the floor of the mouth under the tongue was steadily drawing

the lower lip and soft tissues of the chin wounds. I asked Mr. Shipway, L.D.S. the patient's private dentist to come up to the hospital and consult with me as to the best means of combating this difficulty. We decided to ask Sir Frank Colyer to advise as to further treatment. He very kindly came down from London, and suggested to the surgeon that the only way to stop this contraction was to operate again, remove the cicatricial tissue and line the floor of the mouth with epithelium. Sir Frank Colyer laid great stress on the fact that the apparatus eventually designed should be as heavy as possible, being preferably made of metal.

The first difficulty was the question of some retention apparatus to hold the 'epithelial inlay' in position until union had occurred. The floor of the mouth anterior to the tongue was filled with Stent's composition and carefully moulded as far as possible to the original contour of the chin. This, when hard, was held in position while a composition impression was taken of the lower part of the face. A model of this facial impression was cast, and a metal splint made of aluminium, struck up to fit the model. Two processes of metal were carried up over the lower lip and bent round so as to hold a lump of Stent's composition material firmly in the floor of the mouth.

On March 9, 1923 the first operation was done and on March 28 the cicatricial tissue was freely cut away, composition being carefully moulded to the floor of the mouth and firmly fixed to the 'processes' coming off the chin splint. The splint and the attached composition were removed from the mouth, and the Thiersch grafts carefully laid on the under surface of the composition. The whole appliance was then dropped into position, a four-tail bandage being attached to the splint, for which slots had previously been cut, and fixed round the head in the usual manner. When the apparatus was finally in position with the mouth firmly held by the splint in the half-open position, a tracheotomy was found to be necessary, as the mass of composition in the floor of the mouth was holding the tongue back and so impeding respiration.

On April 5, eight days later, the apparatus worked loose and had to be hurriedly removed. I may say that during this time the patient was very helpful in keeping as still as possible, despite considerable discomfort from uncontrollable salivation, etc. The skin-grafts were found to have adhered very well to the floor of the mouth.

On April 7 I took impressions in plaster-of-Paris and designed, with the help of Mr. Wright, my mechanic, an appliance for the lower jaw consisting of Weston's fusible metal. The metal was cast round six front teeth and a slot running backwards from the region of the second premolar was cut on each side. A Victoria metal lining was soldered into these slots, and the usual bolts and swivels were soldered into the appliance anterior to the slots so that the springs when attached would work and lie in the grooves. An ordinary upper vulcanite plate was made carrying six front teeth, with vulcanite blocks in the molar region. Slots similar to those cut in the lower were made in the vulcanite blocks and lined with Victoria metal. Bolts and swivels were attached in the usual manner in front of the slots. This special arrangement for the springs to work in the slots or grooves was necessary, owing to the previously mentioned difficulty regarding the dragging inwards

of the stumps of the ascending ramus. Springs fitted in the ordinary way would have jammed against these stumps and interfered with all movement.

When the appliance was ready to put in the mouth, I found to my disappointment that shrinkage had again taken place, though not to such a considerable degree as occurred after the original operation. The lower appliance was too large and had to be remodelled to a new impression. In order to avoid this accident occurring again, I had a metal base, without teeth or grooves immediately cast to the new impression, and arranged for

the patient to wear it as long as possible each day. The completed apparatus was finally put in the mouth on April 20.

I found that not only did the wearing of the appliance stop all further shrinkage, but it became possible from time to time, gradually to increase the size of the trough in the floor of the mouth by additions of Stent's composition to the outer surface of the appliance. These composition additions were finally replaced by an addition of Weston's fusible metal to the original appliance.

The patient left the hospital on June 7 having grown a beard (*Fig 351*). His speech and appearance were fairly good, his chief difficulties were masticating and somewhat uncontrollable salivation.



FIG 351.—Portrait of patient ten months after plastic operation.

From the dental point of view, I wish to express my thanks first to Sir Frank Colyer for his interest in the case and his invaluable suggestions. Secondly, I feel very much indebted to my mechanic for his skilful work and help in designing a suitable apparatus for a very rare type of case.

The patient originally saw Mr Shipway regarding the increasing size of his lower jaw, who sent him in to the hospital for advice and treatment. Mr Shipway followed up the case with me and is now keeping a periodical watch on the patient.

REFERENCE

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VISITS TO SURGICAL CLINICS AT HOME AND ABROAD

SOME OF THE SURGICAL CLINICS OF STOCKHOLM.

(SEPTEMBER 22-26, 1923)

WE first visited the Clinic of Professor Gösta Forssell and his colleagues at the Radium Institute. This is a hospital of thirty-two beds with a very complete out-patient department and facilities for treating patients with radium and X rays. It was founded by the Cancer Society of Sweden in 1917, and is now recognized by the Government, which pays the travelling expenses of the patients, who thus have no excuse for not coming as often as is necessary, not only for treatment, but also that their after-progress may be watched. There were 832 in-patients during the last year, and 1533 treatments with radium were carried out, the clinic possesses 1353 mgm of radium. There are five sets of apparatus for deep X-ray treatment, 6200 'deep treatments' were given last year. There are two sets of diathermy apparatus. The hospital is the only one of its kind in Sweden, and draws its patients from the whole country. Some operable cases of cancer are treated, but only those in which ample experience has shown that the results are as good as, or better than, those which follow ordinary surgical removal. Among such cases are those of cancer of the face or skin elsewhere, the neck of the uterus, and external sarcomas. In all other conditions only inoperable cases are dealt with, so that the latter form the vast majority. Diathermy is being used more and more, and last year 155 operations by this method were performed. Very often electric coagulation, radium, and X-ray therapy are used in conjunction. The diagnosis of all cases is determined by removal of a portion of the growth and microscopical examination.

The wards were visited and a series of cases demonstrated. They were frankly discussed and some were extremely interesting. Those worthy of special mention were (1) Sarcoma of the nasopharynx, inoperable in 1921, now apparently well after treatment with radium and X rays, (2) Three cases of malignant disease of the thyroid with apparent cures—one a case of cancer, the other two of sarcoma. The case of cancer of the thyroid was in a woman, age 45, who had been operated on in January, 1921, as it was then thought to be a case of simple goitre. As the growth proved malignant, the operation had to be abandoned. X-ray treatment was given in February and April, 1921, with very little benefit. In May and June deep X-ray therapy was used with some benefit, but the symptoms of myxœdema gradually developed. This was treated with thyroid extract and the X-ray therapy was continued. By November there were no signs of malignant disease, and since that time she has progressively improved. The myxœdema

has been treated successfully by the administration of 3 egm of thyroid extract daily, and at the time of our visit the patient was apparently quite well.

The two cases of sarcoma of the thyroid which were shown were both women over forty years of age. Each had been treated by X rays. One had been free for five years from any symptoms of sarcoma, but had myxœdema, which was being treated successfully with thyroid extract. The other had been free for eleven years from any symptoms of sarcoma, and no symptoms of myxœdema had developed. Great stress was laid on the fact that the larynx must be protected adequately when radium treatment is carried out on the thyroid gland. It was stated that 13 cases had been reported from Germany in which the laryngeal cartilages had necrosed as a result of the treatment.

A case of cancer of the tongue and the floor of the mouth adherent to the jaw was next seen. The growth had been removed by diathermy in June 1923. Two weeks later the external carotid was tied, and as much as possible of the metastasis in the glands excised by the same method. On Sept 19 radium was buried in the remaining mass in the neck. When we saw the case there was a large open wound of the cheek, with at least an inch of the lower jaw exposed and necrotic, but it was asserted with confidence that this would separate as a sequestrum and that later a plastic operation would be done to deal with the defect.

It was stated that, as a general rule, the area of lymphatic drainage was not dissected out unless very obviously involved. For example, a case of epithelioma of the vulva was shown in which the growth had been excised locally by diathermy. The glands had not been touched, though on the left side they were very much enlarged. It was intended to treat them later on by X rays and to follow up the case.

On the other hand, in the treatment of any other metastatic mass clinically inoperable, as much as possible was removed, and the remainder treated with radium and X rays.

An operation for the removal of the breast for cancer by the diathermy method was then carried out. The case was one quite operable by ordinary methods. The passive electrode was fastened to the forearm of the same side. The anæsthetic used was chloroform, which was very well administered by a nurse. The breast was removed together with the axillary glands, the origin of the pectoralis major from the ribs, and the whole mass was dissected up towards the axilla, together with both the pectoral muscles. There was no hæmorrhage whatever. As the axilla was approached the larger vessels were caught in clips, divided, and tied as soon as they were seen, in order to prevent the spread of thrombosis into the axillary vein, with subsequent risk of embolus. The axillary vessels were cleared and the gland was removed as if with an ordinary scalpel, and just as thoroughly. The fascia over the rectus abdominis was not touched. After removal of the breast, the whole of the large, raw area was cooked by diathermy using both electrodes with flat terminals about one inch away from each other. Of course there was no possibility of getting the skin together, and in fact, closure of

the wound is never attempted. The time taken for the operation was one hour. In favour of this procedure it was urged that there was less shock, there was no pain afterwards, and the removal of the growth was just as thorough as by ordinary dissection, and there was no risk of implanting cancer cells. It is claimed that, while by ordinary operative measures surgeons have to admit 25 per cent of local recurrences, this method gives only 5 per cent. As the method has been in use for only two years at the Institute it was frankly admitted that it was much too soon to speak with any certainty. Moreover, apparently inoperable cases could be treated much more thoroughly, for example, if the growth was fixed to the ribs, the latter could be treated by diathermy and the cooking continued down to the pleura. The 'cooked' part of the ribs would subsequently separate as a sequestrum, and in one case the exposed surface of the lung healed into the wound. As a rule it took three months to granulate up after the operation, skin-grafting was not often necessary, and, if done, was usually unsatisfactory, owing to the fact that all patients were treated with X rays for six weeks after the operation. Several patients who had been operated upon by this method were then shown in various stages of their convalescence and after. They all agreed that they had suffered no pain, the use of the arm was excellent, there was no example of 'swollen arm', and the scars were soft and movable.

Dr J. Heyman, who is in charge of the gynaecological cases, then gave us some statistics of cases of cancer of the cervix treated at the Institute. These had recently improved, as most of the gynaecologists now sent all their cases of cancer of the cervix for treatment, it being recognized that the results were better than those obtained by the Wertheim operation, and that a smaller primary mortality was involved. They were treated by diathermy, radium in uterus and vagina, and deep X-ray therapy.

Altogether this visit proved extremely interesting and suggestive, and was a great tribute to the work being done under the stimulating personality of Foissell. The way in which he displayed the efforts of his assistants was quite charming, and, as everywhere in Sweden, they were all so considerate as to address us in English, only occasionally having to be helped out by a Swedish surgeon from Kolmar, Dr Edwin Helling, who acted as a willing interpreter and a delightful guide throughout the whole of our visit.

In the afternoon a visit was paid to the Clinic of Professor Jacobaeus at the Serafimer Hospital. The Professor demonstrated his method of thoracoscopy on a case in which he had attempted to produce artificial pneumothorax for the treatment of tuberculosis of the right lung. The patient was a man about 23, a diabetic who had been treated for this malady without success, and as the Professor said, was 'surely lost', when insulin was tried with dramatic effect. The lung infection had developed after the diabetes. The skiagram showed that the lung had not collapsed, owing to an adhesion between the parietal and visceral layers of the pleura. The Professor thought that the adhesion was not very broad, and proposed to divide it with the electric cautery under direct vision by means of the thoracoscope. The operation was done under local anaesthesia. The patient lay on his left side with the right arm above his head. The thoracoscope was introduced into the right pleural cavity at the 7th intercostal space in the posterior scapular line.

After a short preliminary search the adhesion was found and demonstrated to all present. The special electric cautery, devised for this purpose, was then introduced through a cannula about one quarter of an inch in diameter at a corresponding point at the same level on the front of the chest. When the adhesion was half burnt through, the operation was stopped, in order to demonstrate to all present that this had been done. The division was then completed, and before we left the hospital a refill was carried out, and we were informed that examination by X rays showed the lung to be fully collapsed. The Professor afterwards demonstrated to us a large number of lantern slides, illustrating his methods and cases in this and other branches of medicine.

On Monday, Sept 24, a visit was paid to Professor Einar Key's Clinic at the Maria Hospital (*Fig 352*). This is an interesting old building, which was originally a private house, dating from 1675. In 1817 it was a factory, in 1850 a Maternity Hospital, and since 1905 it has been a surgical 'Lazaret'. Professor Key's private room dates from the first period, and is an interesting vaulted apartment, now decorated with mural paintings.

The first operation was a thoracoplasty for tuberculosis of the right lung in a woman, age 35. The local anæsthetic was 1 per cent novocain. Professor Key removed about 6 inches of half-a-dozen ribs, beginning at the 10th, up to and including the 5th. The anæsthesia was perfect. The operation took forty-five minutes. There was but little shock. The patient sat up after the operation and had the bandages applied. The operation is done by Professor Key in two stages, with an interval of two to three weeks. He made a great point that the angle of the rib must be included in the resected portion. The lower ribs should always be done in the first stage. In the second stage the upper four ribs—always including the 1st rib—are removed. It is not difficult to remove the 1st rib, if one works from below upwards, but it is very difficult—even dangerous—to begin with it. Key has an extensive experience of this operation, and we saw several cases in his wards. The patients usually come direct from the sanatoria for the operation, and then are able to return in from six to eight weeks. During their stay in the Maria Hospital they are treated in the general wards.

The next operation was for cancer of the stomach, but the glands were much involved and there were secondary deposits in the liver, so that no radical operation was feasible. Palliative gastro-enterostomy was not performed. The abdomen was opened in the middle line, and was closed with one layer of catgut sutures and then the skin sutures, no deep sutures being used.

Two cases were then operated upon for tuberculous epididymitis. The first was a man, age 30, whose left kidney had been removed seven years previously for tuberculous disease, and who now had both the right and left epididymis involved. A scrotal incision was used, and epididymectomy performed on each side, as much of the vas as possible being removed at the same time, but without extending the incision. The wound was closed without damage after very careful hæmostasis. In the second case only the right side was involved, and epididymectomy was carried out in the same

way In Dr Key's opinion, this rather than orchidectomy is the operation of choice

Dr Key then went round his wards and showed several patients with tuberculosis of the lung who had been treated by thoracoplasty The Professor also demonstrated, by means of lantern slides, the technique of Reissler, which he employs in the treatment of fractures A woman, age 59 was operated upon for ununited fracture of the neck of the femur by insertion of a bone peg cut from the tibia This was done in June and the result seemed very satisfactory, but the patient had not yet been out of bed In this method screws and nails are used rather than plates The cortex of the bone is tapped to receive the head of the screw He emphasized the point that fractures should be operated upon as soon as possible after their occurrence and compared the urgency of operating upon fractures particularly spinal

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FIG 352—Professor Einar Key's Clinic 1 Professor Einar Key 2 Professor Akerlund

fractures of the tibia, with the urgency of operating upon acute appendicitis and strangulated hernia He also demonstrated, by means of lantern slides, a case of diaphragmatic hernia in which the stomach was in the thorax An ulcer had developed on the lesser curvature and this had leaked The stomach had been resected in the thorax by Polya's method and then the hernial contents returned to the abdomen, and the opening in the diaphragm closed, the patient making an uninterrupted recovery No abdominal incision had been made in this case He showed lantern slides of another case, in which there had been difficulty in swallowing in a man, age 58 From the radiogram there appeared to be a tumour in the mediastinum, this was removed by transpleural operation, and turned out to be a large calcified gland

Demonstrations were then made by the radiologist of the hospital, Dr

Alsa Akeilund He first showed his spinal secondary diaphragm a modification of the Bucky-Potter diaphragm The radiograms taken with the aid of this apparatus were excellent and showed much more detail than is usually seen He also demonstrated a series of radiographs of duodenal ulcer in which the findings were exactly analogous to those of gastric ulcer The ulcer could be seen there was a corresponding niche with retraction and an eccentric position of the pylorus Akeilund insisted that in order to obtain these results a careful technique was required, and especially an intimate co-operation between fluoroscopy and roentgenography He recommended examination in an upright position

On Sept 25, we visited the Morby Hospital and Clinic of Dr K H Grietz This institution is seven miles out of Stockholm, and we were due at 8 o'clock, but the early morning drive through charming country was most enjoyable He first operated upon a tuberculous kidney using a lumbar incision, which was held widely open by a powerful rib separator The kidney, with about eight inches of the ureter, was removed The next case operated upon was an ulcer of the stomach with hour-glass contraction The distal portion of the stomach with the ulcer was removed The resection was commenced by ligaturing the right gastro-epiploic artery at the proposed site of section, thus enabling the lesser sac to be opened this allowed traction to be made on the stomach, and it was contended that the coronary vessels were thus more easily identified and ligatimed The continuity of the gastro-intestinal canal was restored by uniting the jejunum to the posterior wall of the stomach by Roux's method en Y The time occupied was one hour fifty minutes, great care being taken with the large amount of suturing which the method entailed If the Polya method had been followed, the operation would probably have lasted just over the hour

The Professor next operated on a case of osteitis fibrosa of the upper end of the left femur in a girl, age 16 The diagnosis was doubtful Clinically it was tuberculous but the radiologist said it was osteitis fibrosa Some curious-looking material was scooped out of a cavity in the great trochanter and the space left in the bone filled with a fat graft The pathologist examined the material removed, and before we left the hospital we learned that he confirmed the radiologist's opinion A series of cases were then demonstrated, including one of general thyroid malignancy, and two of general adrenal malignancy Of the latter, in one case a tumour reported to be a hypernephroma had been removed from the left humerus, but no tumour could be found clinically in the renal regions in the other a hypernephroma had been removed from the brain, but no renal tumour was demonstrable This hospital has a very large amount of material, and we were informed that about 2000 operations were performed yearly by the Professor and two assistants On the afternoon of our visit a further series of operations were carried out, including two other cases of resection of the stomach

In the afternoon a visit was paid to Sabbatsberg's Hospital, to the Clinic of Dr Hybbinette This is the Municipal Hospital, and contains 800 beds Dr Hybbinette first demonstrated, by means of lantern slides, several cases of bone-graft, and afterwards showed the actual patients They included bone graft for syphilitic deformity of the nose and for plastic operation on the

lower jaw after removal for tumour. In the latter case an excellent ramus had been made from the crest of the ilium. He then showed cases of arthroplasty of the hip-joint, the first case being one of congenital hip disease in a man, age 22. In this case a new acetabulum had been made with a bony fat inserted into it and the head of the bone fixed into the new joint by sutures through the capsule. The functional result was good after this operation, but there was inversion of the leg. The femur was therefore divided and the lower fragment externally rotated, so that the foot was in good position. The result obtained after the second operation was excellent, the man walking with great comfort and being able to flex the hip-joint. The second case of arthroplasty was undertaken for septic arthritis which had produced ankylosis of both hip-joints and one of the knees in a child, age 14. Arthroplasty had been done on the left side and osteotomy of the neck of the femur on the right side, with the object of making a pseudo-arthritis. The knee-joint had not been touched. The result was very satisfactory.

Lantern slides were shown illustrating cases of recurrent dislocation of the shoulder-joint, particularly one in a man about 40 years of age. It was maintained that in these cases there is always a defect in the lower margin of the glenoid cavity due to fracture. If a radiograph is taken with the arm fully extended above the head, this defect can always be seen. Dr Hybbinette treats such cases by a bone-graft from the tibia to fill up the defect. He does no slinging operation. He maintained that he got perfect results.

Two cases were demonstrated of myeloid sarcoma of the shaft of long bones, one being of the tibia which was excised and a graft put in from the opposite tibia. The result shown was perfect thirteen months after the operation. The other case was that of a girl, who at the age of 16 had a spontaneous fracture of the left humerus, due to what appeared from the X-ray to be a myeloid sarcoma. This case was treated with splints and deep X-ray therapy. The fracture united and the sarcoma disappeared. As there was no operation, the diagnosis is in doubt in this case.

The last case shown was a woman, age 47, the subject of successful embolectomy. She had a valvular lesion of the heart. The embolus had lodged in the left femoral artery, where the profunda is given off. The operation was done six hours after the onset. The embolus was removed and the artery stitched up and when we saw the patient eighteen months after the operation, she appeared to be perfectly well, with normal circulation and function in the limb.

After the demonstration a visit was made to the wards and to the operation theatre. The first operation was an arthroplasty for ankylosis of the proximal interphalangeal joint of the middle finger following acute sepsis. The ends of the bone were shaped by means of a burr, and a graft of fascia lata was inserted between them after division of the extensor tendon, the tendon was stitched up after the fascia lata had been fixed in position. This was a troublesome little case, which was very neatly handled by the Professor and his assistants.

The next operation was a muscle-graft for paralysis of the quadriceps, the result of anterior poliomyelitis. The biceps and gracilis were grafted to the patella. The other leg had been similarly treated fourteen days previously.

On the same evening, we were entertained by the Swedish Society of Physicians at their weekly meeting. They meet in a commodious, three-storied building erected two years ago by the Society. On the ground floor there is a large lecture room, with accommodation for about 300, and here the weekly meetings are held, on the second floor is a large library with reading and committee rooms. The upper floor is used as a social club, and contains a spacious dining room, where supper is served after the meetings. The Swedish Society of Physicians was founded in 1808. It has met every Tuesday evening since, except during two months in the summer of each year, when no meetings are held. In addition to what might be called the General Meeting on Tuesday evenings, when papers of general interest are read and discussed, there are subsidiary sections embracing the various specialties, these meet on different evenings to discuss more 'specialist' papers. Many distinguished British medical men have been elected members amongst others are the names of Astley Cooper (1813), Edward Jenner, Richard Bright, William Bowman, James Syme, Thomas Huxley, Joseph Lister (1881), Ronald Ross, Victor Horsley, John Langley, and William Osler. The Retzius Gold Medal has been awarded to Professor Langley (1912) and to Sir Charles Sherrington (1922).

On the occasion of the Club's visit the first paper read was by Professor Aschoff on "Infection and Re-infection in Tuberculosis of the Lung." The Professor is an excellent speaker, and his address was very well received by the large audience.

He was followed by Professor Einar Key, who read a paper on the "Treatment of Tuberculosis of the Lung by Thoracoplasty", detailing *his experiences of the operation since he commenced the series in 1915*. He has operated upon 60 cases, and, though a sufficiently long period has not yet elapsed to judge of the ultimate result, at the present time, 4 out of the 7 cases operated upon in 1916, and 4 out of the 11 cases operated upon in 1917 are back at work and free from symptoms. Up to the year ending 1921, out of 51 cases operated upon, 15 are back at work and free from symptoms, 10 are improved, 5 were made worse, 5 died shortly after operation, 11 died subsequently of tuberculosis of the lung, and 5 of some other disease. The lecturer laid great stress on the necessity of doing the operation under local anaesthesia and in two stages. The paper was discussed by Professor Jacobæus, who had made the diagnosis and examined the chest in the cases related by Key, both before and after operation. He stated that in all but 3 of the 60 cases there were signs of the other lung being affected, as determined either by clinical examination or by X rays. The general rule is to wait for six months after deciding that operation might be of benefit. If at the end of that time there is no change in the less affected lung, then the worse side is operated upon. The disease on the less affected side may be aggravated after the operation, but the ultimate result on the whole may still be good.

Dr Olivecrona then showed the specimen and read the notes of a case on which he had performed embolectomy of the right femoral artery on Sept. 22. This day was a Sunday during our visit, and the speaker had very kindly tried to get in touch with the members of our party nightly

thinking that they would be interested in the operation. The case was of exceptional interest, as the patient had an embolus successfully removed from the left femoral artery twelve months previously by another surgeon.

The patient was a woman, age 40, who had suffered from valvular disease of the heart for many years. On many occasions there had been pulmonary emboli, and once an embolus in the right kidney. On Sept 21 she noticed pain in the right foot. Next day at 2 p.m. the right foot and lower part of the leg became numb and the pain very severe. She was taken straight to hospital, and at 4 p.m. the diagnosis of embolus in the right femoral artery was made. The right foot was cold, and this coldness extended to a point five inches below the knee-joint. There was anaesthesia of the right foot to light touch, and the sensation of prurick was delayed. No pulsation could be felt in the popliteal artery, but it could be felt in the femoral artery just below Poupait's ligament. A blood-pressure apparatus showed no oscillation when applied anywhere to the right leg, except just below Poupait's ligament. The exact site of the embolus could not be determined. The popliteal artery was first explored under local anaesthesia but it was found empty. The femoral artery was next explored, and an embolus found to be lodged just where the profunda branch was given off. The encirculation was controlled by clamps, the artery opened by a longitudinal incision, and the embolus removed. The artery was stitched up by a continuous suture of fine silk. When the wound made for the exposure of the popliteal artery was stitched up, there was good pulsation in the popliteal artery. Four hours later the foot was quite warm. The specimen shown had three clots attached, as if showing the division of the femoral artery into the profunda and superficial branches.

The development of the operation of embolectomy is largely due to Dr Emai Key. An important paper on the subject by this surgeon was published in *Surgery, Gynecology and Obstetrics*, March 1923.

On Sept 26, we visited the old University town of Upsala made famous in the history of surgery by the late Professor Lennander. A new hospital is well advanced in the process of building. The old clinic, dating from 1860, is still in use, and it was there, in a very old-fashioned operating theatre that we found Professor Nystroem at work.

The first operation performed was for fixation by the Albee method in tuberculous disease of the spine. The patient was a boy, age 14, who had been treated by Professor Waldenstrom's method for six months, whereby the angular curvature had been reduced from 90° to 30° . Scoliosis was present as well. It was notable that the Professor did not wear gloves. The usual curved incision was made, the spines above and below the site were divided by a circular saw, and the division was deepened by a chisel and hammer. The graft which was taken from the tibia included the periosteum.

The second operation was undertaken for a fracture of the right humerus four months previously in a woman, age 65, in which a false joint had formed. This was a very difficult proceeding. Ultimately the bones were got into good position, and a bone-graft taken from the tibia was inserted.

He then demonstrated some cases, more especially his method of treating huge chronic ulcers of the leg. In all cases the Wassermann reaction was

done first. If any varicose veins were present, these were excised as a preliminary operation, but the rarity of their occurrence in these cases was commented on. As a preparatory treatment, patients were kept at absolute rest for two weeks, during which the ulcers were dressed with subacetate of lead. The operation consisted of a very wide and free excision of the whole ulcer, well beyond the apparent edge, with all the scar tissue down to the muscles and tendons. All fascia was excised, but the periosteum of the tibia was carefully preserved. Haemostasis was attended to most carefully, and then the whole surface was immediately skin-grafted by the Thiersch method. A very porous dressing was applied so that any discharge could get through. The anaesthesia was either local or spinal. In the cases shown the ulcers



FIG. 353.—Professor Waldenstrom demonstrating his method of preliminary treatment of kyphosis in tuberculous caries of the spine.

were healed. No details as to the number operated upon were given, second operations had sometimes been done.

Dr J. W. Nordenson gave a demonstration in the Ophthalmic Department of Professor Gullstrand's lamp and ophthalmoscope. With the latter the disc and macula was seen magnified one hundred times.

Some of the members visited the Department in charge of Professor Barány, of international otology fame.

In the afternoon a visit was paid to the old anatomical theatre of Upsala, where public dissections were made in the time of Olaf Rudbeck (1630-1702), the Swedish anatomist, who shared in the discovery of the thoracic duct.

On Sept. 26 the Clinic of Professor Henning Waldenstrom at St. Görans

Hospital was the rendezvous. In the wards we saw patients undergoing various forms of treatment. The cases were all children, and mostly examples of tuberculosis of the bones and joints. Those in the Finsen light rooms included bone tuberculosis with sinus formation and cases with amyloid disease. All showed remarkable improvement under this treatment. Details of the treatment of tuberculous disease of the spine were fully discussed. Before doing any operation for fixation in these cases, great stress was laid on the necessity of the preliminary treatment to reduce the kyphosis as much as possible. This was done by rest and splinting by the 'Waldenstrom' method which is much as follows. Immediately on admission the child has a plaster jacket accurately fitted to its back while it is lying on its belly supporting the chin with both hands the elbows being on the bed. This jacket is then suitably padded and the child lies in it until the gibbosity disappears or becomes stationary. The jacket is raised from the bed by a wooden support so that the spine is extended. The child is never allowed to sit up for any reason whatever. It is turned by two nurses one at the shoulder, the other at the buttocks. Each week more wool is put into the jacket under the gibbosity, so that the pressure on it is increased (*Fig 353*). The average length of time for this preliminary treatment preceding operation, is eight months. So far as the graft is concerned, the Professor insisted that it must extend at least the length of two vertebrae above the disease and two below.

An operation was done on such a case in which this preliminary treatment had been carried out. The spines were split with a Hey's saw and the cut was deepened with a knife, there was very little trauma. The graft was taken from the tibia and included the crest. In adults it is impossible to get cancellous bone if the crest only is taken. It is therefore cut from the subcutaneous surface of the tibia. The graft in the case we saw was fixed in position by silk ligatures. The patient's own jacket is replaced after the operation. He is turned only twice in two months. After being in bed for two months he is allowed up with a corset. The case operated upon would wear a corset for a year at least. Professor Waldenstrom then gave a lantern demonstration of his method of treatment. He had operated upon 101 cases in the last ten years. The results shown were excellent, and included patients of all ages.

This brief account of our visit supplies only an outline of what we saw, but it would indeed be incomplete if it did not mention the many kindnesses and the unbounded hospitality which met us everywhere.

A STUDY OF INTRACTABLE PAIN RELATIVE TO RHIZOTOMY AND SPINAL SECTION.

By R C SHAW, MANCHESTER

AT a meeting of the Surgical Section of the Royal Society of Medicine in 1911 Mr Hey Groves, in a paper on rhizotomy, drew attention to the fact that whilst section of the posterior spinal roots was followed by fairly satisfactory results in cases of spastic paralysis, this procedure was not effectual for the treatment of intractable neuralgias. There was a failure of rhizotomy to cure pain in about 75 per cent of cases. Again, in a paper published in the *BRITISH JOURNAL OF SURGERY* of October, 1914, a synopsis of the results of rhizotomy in the hands of its leading British exponents showed very little progress towards the permanent cure of pain of this character. An analysis of 15 cases of rhizotomy exhibited 8 complete cures, but of this number 3 had pain in a strictly localized peripheral area involving only one spinal root, and were relieved by division of that root, a feature which places these examples in a group peculiar to themselves, contrasting strongly with the large majority of cases with intractable pain treated by rhizotomy. Thus, of the 8 cures only 5 may be said to typify the average form of case encountered. Of the remainder of the 15, 4 were complete failures, and 3 may be discounted owing to complications. Turning to the results of posterior rhizotomy for the painful crises of tabes dorsalis, the figures are more encouraging, in Forster's hands the percentage of completely cured is given as 49, and of the remaining 51 per cent which represents total failures and cases improved but not cured, the latter form 33 per cent, whilst the English percentage of cures would appear to fall below these figures.

The failure of posterior rhizotomy to abolish pain in the great majority of these cases is a striking feature when compared with the successful post-operative results following excision of the Gasserian ganglion in cases of persistent trigeminal neuralgia. In 1902 Krause had had no recurrence of pain in any of his 36 cases of gasserianectomy, whilst Keen in 1898 had 2 relapses out of 14 cases, and these were due to incomplete operation. Morphologically the Gasserian ganglion corresponds to the ganglia on the dorsal spinal roots, being anatomically in association with the same type of fibre, and yet we are faced with the anomaly of divergent results on extirpation of these structures, pain invariably being relieved in the one case, but in the spinal region frequently recurring. In this association it may be apposite to draw attention to the fact that a psychical element, although indubitably present in many cases of long-standing pain, as shown by a variable degree of hysteria, is not in any way accountable for the majority of failures in spinal rhizotomy, for, in the first place, cases exhibiting pronounced hysterical symptoms have been definitely cured by root resection, whilst in none of these cases is the pain more severe than in those of trigeminal neuralgia,

which from its anatomical situation and connections one might expect to make a more pronounced psychical impression than, for example, an equally severe pain in the lumbar region, and yet as we have seen from the post-operative results, root-resection or extirpation of the ganglion of the fifth nerve is an eminently satisfactory procedure, factors which weigh heavily against a psychological explanation of the failures in dorsal rhizotomy.

The persistence of the pain after the severance of what is held to be the principal afferent path to the central nervous system gives grounds for the supposition that an accessory-sensory channel may exist.

In studying the results of posterior rhizotomy, the phenomena may be divided into two groups (1) *Objective*, (2) *Subjective*.

Objective Symptoms—In this group we have for consideration the resultant anaesthesia. Dealing primarily with the cervico-dorsal rhizotomies, the cases fall into two classes—those which present complete anaesthesia to all the usual stimuli, and those in which it is incomplete. Among the latter is a case of Horsley's, reported by Head, of posterior rhizotomy of the 5th, 6th, and 7th cervical roots for neuralgia. In this subject there was no loss of deep sensation above the wrist, nor of vibratory sense in the forearm and arm. In such a case there is always the possibility of overlap from the 8th cervical or 1st dorsal roots. Hey Groves reports a case in which he performed rhizotomy of the 6th, 7th, and 8th cervical and 1st dorsal roots for spastic paralysis of the arm, in which the anaesthesia was confined to a strip along the ulnar side of the hand and forearm, including the little and ring fingers, and ceasing two inches above the elbow. The spinal segments usually assigned to the forearm and hand are the 6th, 7th, and 8th cervical and 1st dorsal. Are we to accept this case as an example of extensive overlap from the 5th cervical? A patient of Sir William Thorburn's, where resection of the lower four cervical and 1st dorsal posterior roots had been performed manifested deep sensibility everywhere in the affected arm, whilst cutaneous anaesthesia was very patchy. An interesting light is thrown on the behaviour of these areas of sensation after posterior rhizotomy by the following two cases.

In the first example a patient of Abbe's suffering from brachial neuralgia, the left 6th, 7th, and 8th cervical and 1st dorsal posterior roots were resected, followed by complete anaesthesia in both front and back of the left hand, extending one to two inches above the wrist, and also on the dorsum of the forearm, and the side and dorsum of the upper arm to about halfway above the elbow, elsewhere sensation was completely retained. Re-examination of the same patient seven years later demonstrated only diminished tactile sense for the ulnar and median distribution, with analgesia over the same area, whilst above the elbow there was no gross disturbance of sensation.

The other case, a patient of Bennett's, was suffering from acute crises of pain in the left leg which had proved intractable to peripheral operation. Posterior rhizotomy was performed on the lower 4 lumbar and 1st sacral roots, immediately following operation, anaesthesia was complete in the limb areas corresponding to the severed roots, but during the remaining twelve days, before the patient succumbed to a cerebral haemorrhage there was a steady and progressive restoration of sensation in the anaesthetic area, so much so that the operator was satisfied that if the man had lived the restoration

would have been to an almost normal degree. Post-mortem examination showed that there had been no re-union of the severed roots.

It will thus be seen from these two widely separated cases that there may be a slow or rapid regain of the lost sensation in the areas of the cut roots. From the objective side alone it is clear that some further explanation of the incomplete anaesthesia and recovered sensation must be sought beyond that of nerve overlap from adjacent unsevered roots.

Turning to the cases of pain crises in *tuberculosis dorsalis*, a similar inconsistency of the effects of posterior rhizotomy on the objective sensory phenomena may be instanced, both of which passed under personal observation. In the first case, suffering from severe gastric crises, Sir William Thorburn had performed posterior rhizotomy of the 5th to the 9th dorsal roots, with resultant complete anaesthesia of the skin from the 5th rib to the umbilical plane on the left side, whilst a tactile sensation was retained in the muscle wall, deep pressure stimuli being localized to within one inch of the point of maximum stimulation. In the second case, also for gastric crises, the same operator had resected bilaterally the 5th to the 8th posterior dorsal roots. Examination of this patient six years later showed a corresponding cutaneous anaesthesia from the level of the 5th rib to a plane passing a little above the umbilicus, but, as in the former case, tactile sensation in the deeper tissues was perfectly retained over this entire area, the stimuli being fairly accurately localized. The laxity of the skin in both these subjects rendered it an easy matter to stimulate the same apart from the deeper tissues, the patient being entirely unaware of the strongest pressure or prick stimuli, whereas the slightest pressure on the muscle wall was readily appreciated.

Subjective Symptoms.—Under this heading the effects of posterior rhizotomy on pain will be considered, primarily in the limbs. Of the large proportion of neuralgia cases that relapse after operation, some have recurrence of pain immediately after recovery from the anaesthetic, whilst in others relapse does not occur until weeks or even months have passed. Considering the former first of all, in a case of Abbe's where the 6th, 7th, and 8th cervical and 1st dorsal posterior roots were resected, the patient was free from pain on the first day, but the symptoms gradually returned, and by the fifth day an attack of the former pain had been experienced in the outer side of the forearm, and hand. After fifteen days the attacks lessened, and from that date for the next seven years, pain was still felt, although it was not so frequent or so severe as formerly. It is evident from this case that part of the trouble was due to irritation of the posterior roots, a supposition confirmed by the pathological examination of the resected roots, which showed inflammatory changes, but it is equally clear that some other sensory channel was also being irritated. A similar inference may be made from a case reported by Chavannaz. The patient, suffering from severe intercostal neuralgia radiating from the axilla to the mamma, had the corresponding intercostal nerves resected without any relief, rhizotomy of the 1st to 4th posterior roots of the dorsal nerves only lessened the pain to a slight degree, suggesting, as in Abbe's case, that another sensory path was functioning although the posterior roots must have participated in the conduction of the irritant stimuli.

Contrasting with the rapid recurrence of the subjective symptoms as

typified by these cases there is a second group which show relapse after an interval often lasting several months. A man of 62 years suffering from acute pain in the right leg is reported by Hildebrand as having five posterior lumbar roots resected the symptoms being completely relieved for nine months when the pain gradually returned to its former severity. Similarly a patient of Knapp's, a man of 25 with excruciating neuralgia in an amputation stump of the right arm had the 6th cervical to the 1st dorsal posterior roots resected, with relief for several months when the pain returned as severe as before, so much so that the spinal theca was again opened and the division of the roots confirmed. A case of Hey Groves's, suffering from persistent neuralgia of the left leg the result of an indolent ulcer over the shin, had posterior rhizotomy of the 4th and 5th lumbar and the 1st 2nd and 3rd sacral roots. After operation there was complete anaesthesia of the affected limb, accompanied by ataxia demonstrating that all usual forms of sensation including anaesthetic impulses had been eliminated along with the pains, the latter, however, recurred after a lapse of several months eventually driving the patient to acute mania. Although there was an undoubted mental disturbance in this case latterly, the psychical affection might be reasonably attributable to the effects of pain, rather than the pain to be cerebral in origin.

In these cases it would appear that some new channel of irritation was gradually opened up under the influence of chronic irritation until the strength of the stimuli again produced conscious recognition of pain.

The same general division with respect to relapse is evident in the tabes cases some having recurrence immediately after operation, others relapsing only after several months. Again, with regard to the effects of rhizotomy on those that recur, many are considerably modified both in respect to the frequency of the attacks and the severity of the pain. About 27 per cent of 64 cases of Forster's were altered in this way, against 26 per cent of total failure showing that, as in the rhizotomies for neuralgia, the posterior roots indubitably share in the mediation of the stimuli, otherwise it is difficult to account for the modification of the pain after their section.

From the preceding review of the clinical effects of rhizotomy one may make certain general inferences:

- 1 That the posterior roots are actively concerned in the conduction of stimuli in the majority of cases. Where posterior rhizotomy cures, this is self-evident, whilst the considerable alleviation of the symptoms after their section in cases that relapse points to the same conclusion.

- 2 That in some cases of posterior rhizotomy of the cervico-dorsal or dorsal region, there is retained a sensibility to pressure in the deep tissues, and that this has been recognized in cases where overlap from normal areas is out of the question.

- 3 That in one case there was a rapid return of sensation in the anaesthetic area although five posterior roots were cut which latter fact was confirmed on post mortem examination.

- 4 That in other cases there is no evidence of any retained sensibility to ordinary stimuli although the pain persists.

- 5 That the recurrence of pain, whether early or late, without evidence

of psychical disturbance in many cases, suggests that another conducting channel may exist

Before proceeding to examine the subject from the physiological side, the indications from three clinical cases as to the nature of this path will be discussed

Case 1, a patient of Thorburn's, was a man of 47 suffering from gastric crises of the painful type, of tabetic origin. The pain was principally seated in the 7th, 8th, and 9th left intercostal spaces and the left epigastrium, accompanied by a localized pain in the latter region. Unilateral posterior rhizotomy of the 4th, 5th, 6th, 7th, and 8th dorsal roots was performed in 1914. At the time of operation it was thought that some of the corresponding anterior roots had been severed, which was confirmed by the atrophy of the intercostal muscles that followed operation. On re-examination of this patient in 1921, the 6th, 7th, and 8th intercostal muscles were seen to be paralysed, accompanied by marked wasting in the corresponding spaces. The area of anaesthesia was found to extend from the 5th rib to the subcostal plane on the left side, and to be complete for both skin and deeper tissues. The patient had not suffered the slightest relapse since the time of his operation. Comparing this case with the two previously mentioned of this surgeon's, the contrast is striking, both the latter had retention of deep sensibility and recurrence of pain, and in both posterior roots only were divided, whilst in the present case anterior roots were also cut. This may be mere coincidence as regards the cure of pain, but, on the other hand, the abolition of deep sensation where the ventral roots were divided is very suggestive of the possible secondary path in these cases.

Case 2 is reported by Kilvington. The patient, a male, age 21, suffered from neuralgic pain in the stump of the left arm after amputation for sepsis following old fracture-dislocation of the elbow. Prior to rhizotomy, resection of nerves had, as usual, failed to relieve the symptoms, the patient always complaining of pain on recovery from the anaesthetic. Finally, rhizotomy of the 6th, 7th, and 8th cervical and 1st dorsal roots was carried out, the section being made extradural, but central to the posterior ganglia, and in each case anterior as well as posterior roots were divided. On recovering from the anaesthetic the patient immediately said that the pain had gone, a relief which stands out in striking contrast to the effects of his previous operations, and up to the date of report, ten weeks after, there had been no recurrence.

Case 3 was a patient of Abbe's, where a man of 46 suffering from old infantile hemiplegia with athetoid movement of the right arm, had increasing neuralgia in the forearm, the arm was amputated at the shoulder, a proceeding which only exaggerated the pain. Rhizotomy was performed, the 5th, 6th, 7th, and 8th cervical and the 1st dorsal posterior roots, with the 6th, 7th, and 8th cervical and 1st dorsal anterior roots, were resected. The results were very satisfactory; the painful spasm and athetosis were permanently abolished, the scar of the amputation became painless, and the health greatly improved although the patient still said he had slight pain, which Abbe attributes to a psychical factor in view of the old-standing cerebral trouble. However, it is clear from the complete cessation of all the major symptoms following root resection that the trouble was principally located peripherally.

The definite cure in the first two cases, including the absence of deep sensation in the tabes case, with the great relief of the last patient despite old-standing cerebral trouble, strongly indicates the ventral roots as the possible accessory channel of conduction of pain impulses. Such would appear to be the general inference from the clinical side, from which we may turn to the physiological investigation of the anterior roots as an afferent path.

THE PHYSIOLOGICAL INVESTIGATION

In the first place it should be noted that practically all our knowledge of sensory fibres in the ventral spinal roots dates not from recent years but from the days of Claude Bernard and his predecessor Magendie. More recent work has been confined to degenerative methods of study on the principle that an endoneural afferent system did not exist, all sensory cells being considered to lie in the extraspinal ganglia. Since it is only the actual physiological responses that can finally settle whether a fibre conveys a sensory impulse or not—evidence which can only come from the clinician or the experimental physiologist—it is of vital importance to the question to sift completely the classical experimental work on this subject, work which has formed the basis upon which our conception of the function of the anterior roots has been built, and which, for general reasons to be seen later, is unlikely to be repeated under its original conditions.

At the beginning of the last century physiologists first made an attempt to distinguish the functions of the dorsal and ventral spinal roots. Walker in 1809, considered that the anterior roots conducted sensory impulses, and the posterior to be motor in function, Lamarek in the same year independently conceived the same idea. It was not until the advent of Bell's work in 1811 that any accurate general conception of the functions of these roots was attained, this investigator, using freshly-killed rabbits, was able to demonstrate the motor nature of the anterior roots, but did not succeed in elucidating the sensory function of the posterior ones. His pupil Shaw went to Paris in 1821, and demonstrated these experiments in the presence of Magendie, who commenced research on this subject, and succeeded in proving the general sensory nature of the posterior roots, at the same time confirming the efferent character of the anterior roots. But it is to be noted that Magendie, with scientific integrity, published his contradictory evidence with respect to the latter series. In 1823 he says, "The signs of sensibility are hardly visible in the anterior roots", whilst in 1839, speaking of the same nerves, he refers to their sensibility as being very manifest. Nevertheless, other workers in this field proved that the general principles of the Bell-Magendie law were also applicable to birds, fishes, and batrachians, the frog of Muller is well known as showing complete anaesthesia on one side and paralysis on the other side of the body, following section in the first instance of posterior, and in the second case of anterior, roots.

The question of the apparent sensory element in the ventral roots was investigated by Longet who declared the non-existence of the same in his work published in 1842, but research on the subject was continued by Bernard who after many experiments, succeeded in showing conclusively that sensation was present in the anterior roots which he concluded to be due to the presence of recurrent sensory fibres passing from the posterior ganglia up the anterior roots to supply the spinal meninges. It was found that if a ventral root were severed stimulation of the peripheral stump alone gave rise to a response in the animal, and that this result was dependent upon the integrity of the dorsal root. It was likewise observed that division of the mixed nerves distal to the junction of the two roots also abolished the sensibility

of the ventral root, from which evidence this investigator concluded that these recurrent sensory fibres crossed from the dorsal to the ventral roots not at their point of union, but in the distal plexuses. The general principles of the Bell-Magendie law were re-studied by Waller, using degenerative methods, and reconfirmed thereby. From time to time, however, non-degenerated fibres were reported in the central end of severed dorsal roots when cut proximal to their ganglia, and the question was finally decided by Tanilli and Panichi in 1902. Using dogs for their experiments, they cut the posterior roots and, allowing for degeneration stained them by the Marchi process, then results showed that the central end contained a few undegenerated and scattered fibres, whilst the corresponding peripheral stump showed similar degenerated ones. It was also noticed that whilst in the cervical and dorsal regions there were only a few of these fibres, they were more numerous in the lumbar segments. From the embryological side Cajal has observed fibres arising as axons of cells in the grey matter of the spinal cord of chicks, growing out by the dorsal roots. The evidence, therefore, from histological and embryological sources demonstrates an exception to the general law in the case of the posterior roots while the results of experimental stimulation such as was carried out by Bayliss and by Steinach in the frog have shown that motor effects follow stimulation of the same but that the effects are dependent upon fibres possessing trophic cells in the dorsal ganglia, which evidence shows that there are at least two exceptions to the normal process of conduction and cell-connection of the fibres in the dorsal roots. The case for the anterior roots was investigated by Schuff in 1850, by section and staining for degeneration, which methods revealed the presence of degenerated fibres in the central ends of these severed roots, confirming the conclusions of Bernard with respect to recurrent fibres possessing trophic cells in the posterior root ganglia.

In view of the fact that all our knowledge of the sensory responses to stimulation of the ventral roots comes from the work of Claude Bernard, it is necessary to review carefully the general results of these experiments. The laminectomies were performed on dogs without anaesthesia and often accompanied by considerable hæmorrhage, whilst the actual testing for sensibility was carried out by pinching the nerve-roots, a positive response elicited a definite cry or movement of the animal. In many of his earlier experiments no signs of any sensory perception were evoked, when in 1846 he appears to have succeeded suddenly in obtaining positive results. A careful study of these shows that the responses which are interpreted collectively in reality fall into two definite groups. (1) Cases where sensation was found only on first stimulation of the roots, immediately subsequent to exposure of the cord after great hæmorrhage, and consequently when the animal was in a condition of maximum shock. In these cases the sensation rapidly diminished. (2) Cases where the response was only obtained after allowing the animal to rest for an hour or two following exposure of the cord thereby permitting the abatement of shock. These facts suggest that the sensory responses are due to widely different factors.

The type of sensation elicited on first exposure and stimulation of the roots is strictly comparable with the sensory phenomena following the stimulation

of the afferent viscerai nerves in man, in the latter, results were obtained over a transitory period in cases where the viscus such as the pelvic colon, was exposed outside the peritoneal cavity. It is therefore possible that this form of sensation is dependent upon a similar type of nerve-fibre passing over or through the anterior roots but whether of recurrent meningeal nature or true afferents to the spinal cord it would be unwise to differentiate.

The second form of sensory response obtained after the subsidence of the major shock appears to be explainable in an entirely different manner. The results were only obtained on stimulating the peripheral end of the cut root, which necessarily caused contraction of muscle. That such a muscular contraction is capable of alarming an animal, is borne out by observations noted during experiments to be detailed later where stimulation of a muscle through the anæsthetic skin following section of three posterior roots resulted in a contraction which alarmed the animal, presumably by exciting unaffected nerves. This result would be more pronounced in Bernard's experiments, where the posterior roots were intact, whilst the abolition of the phenomenon on section of the mixed nerve or the posterior root is quite intelligible.

It is equally evident that when the animal was in a condition of shock such a response might not be obtained, whereas an interval of an hour or two would permit this condition to pass off, whilst the irritable effects of trauma would have increased the excitability of the nerve-fibres. Otherwise it is difficult to conceive that the afferent fibres to the spinal meninges pass from the dorsal root ganglia to distal plexuses and then double back up the motor nerve to their distribution, and, what is more, the spinal meninges are almost insensible to manual stimulation. This was shown in the human subject by a case of Abbe's where the opening of the dura without anæsthesia was unattended by pain. We may glean from these observations that although the general principles of the Bell-Magendie law hold good, there are exceptions to it in the posterior and anterior roots.

The investigation of this hypothetical afferent path was commenced from the histological side on the principle of nerve-degeneration following section of the fibres from their trophic cells. In this connection two possibilities present themselves. (1) The trophic cell might be in the extraspinal ganglia, such as those on the posterior roots or in the sympathetic chain. (2) The cell might be intraspinal, for example, in the lateral horn nucleus or in Clark's column. (*Fig 354*)

If the former were the case section of a ventral root would produce ascending degeneration of the afferent fibres in the root, and in the columns of the cord provided no secondary neurone were intercalated on the tract immediately after the arrival of the axon in the grey matter. If the trophic cell were situated in the spinal cord, section of an anterior root would result in degeneration of the afferent fibres on the peripheral side of the division, which would not be distinguishable from the degenerated efferents. We primarily investigated the effects of anterior rhizotomy in cats. Following a laminectomy an anterior root was hooked into view by a fine wire and divided by an ocular tenotome, from fourteen to twenty-one days were allowed for degeneration, when sections of the spinal cord were taken and stained by the Marchi process. The earliest results obtained showed definite

degeneration in the posterior columns, even in cases which appeared to have been carefully treated, without any known contusion of the spinal cord, but the later results, following increased efficiency in the operative technique and more expeditious procedure showed no trace of degeneration in the spinal tracts. Sections in all cases were cut transversely above, below, and at the level of the lesion, and also longitudinally. As the result of this negative evidence the presence of afferent sensory fibres possessing a trophic cell outside the cord would appear to be eliminated.

The other possibility, that of afferent fibres with endoneurial trophic cells, cannot be excluded by these experiments. At one time it was under consideration to produce mass degeneration of known tracts in a selected segment of the cord, on the principle that the endoneurial cell axons would remain unaffected. Such a procedure would involve double transverse section combined with

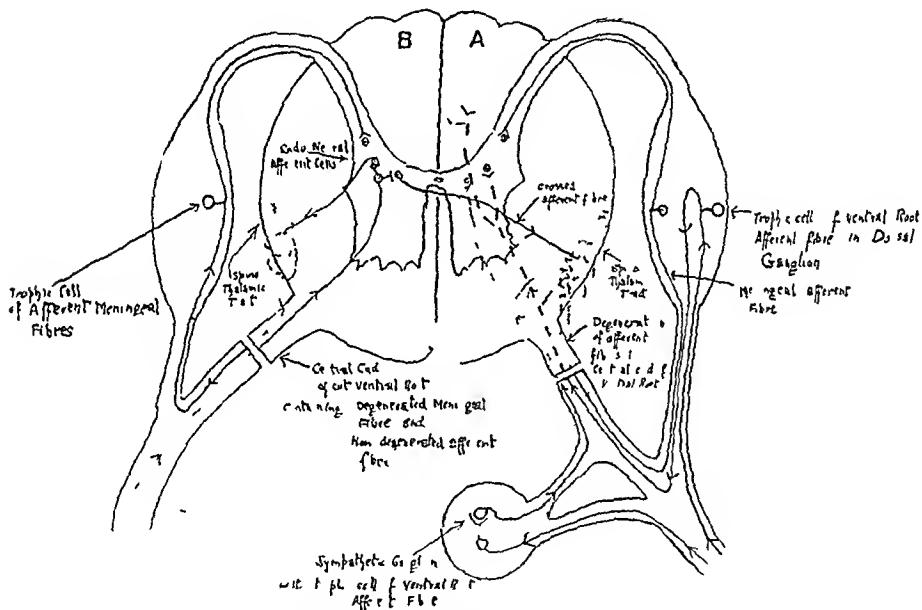


FIG. 354.—Diagram illustrating hypothetical degenerations after section of anterior root afferent fibres from (A) extraneural trophic cells (B) endoneural trophic cells.

Rhizotomy of the roots supplying the segment, unfortunately a fallacy would arise from the ascending and descending collateral fibres, themselves arising from cells in the grey matter. As an alternative it was decided to investigate the effects of rhizotomy on somatic sensibility. Rabbits were the animals selected for these experiments.

Before proceeding to a description of the experiments and their results the methods of examination for sensation will be described. In the first place it is evident that the response of an animal to a sensory stimulus will vary considerably according to its condition and the surroundings and that apart from the signs of actual pain perception as shown by a cry or violent struggling it may appreciate many grades of tactile sensation before such stimuli arise

to consciousness as harmful—sensory appreciation which it is of the first importance to be able to recognize

As the result of repeated study of rabbits, it was noticed that, when examined under quiet conditions, if the head were lightly stroked, the ears were depressed to a medium degree the palpebral aperture was contracted and the head was held still the genicral impression was one of rest. If the stroking was now stopped, the animal usually remained in this attitude for several minutes. It may be mentioned at this juncture that the animals were housed close to the street, consequently, the ordinary sounds from without did not disturb them in the least. When the rabbit had been quietened into the 'rest' attitude the application of a slight stimulus to a normally sensitive skin area arrested its attention which was outwardly manifested by a raising of the ears and a dilatation of the palpebral aperture, whilst if the stimulus was slightly increased, the ears became erect the eyelids were widely opened and the head was held in a strained attitude of attention which frequently caused it to oscillate, at the same time the respirations might be found to be quickened. This degree of stimulus sometimes caused rabbits to look round at the leg that was being pinched, without any signs of alarm or struggling which would suggest pain. The attitude was one of 'awareness'. If the stimulus was now raised to a painful degree the animal depressed the ears strongly at the same time struggling to move away if restrained but only a very painful stimulus evoked a definite cry. By making repeated observations at different occasions on the same animal one was able to appreciate the manner in which the animal responded to the different degrees of stimulation, at the same time frequent observation of the similar type of response eliminated fallacies from adventitious movements.

As for the mode of stimulation, the faradic current was first employed, but it was soon found to be useless on account of the buzzing sound distracting the animals' attention, causing them to be constantly on the alert. For this reason it was not used, the simple pinch-prick stimulus with a sharp pair of forceps being found quite effective.

The line of investigation first adopted was to examine the effects produced on somatic sensation by posterior rhizotomy, following on the indications from the human results, the dorsal region being primarily studied.

EXPERIMENT 1—Rabbit. Laminectomy mid-dorsal region. Posterior rhizotomy, three consecutive roots on left side.

Result—There was complete cutaneous anaesthesia over an area about 1 in wide, extending obliquely round the body to the mid-ventral line. The deep tissues in this area everywhere responded to pinch-prick. Faradic current elicited a slight response over this area, as compared with a very active result on normal skin. In this experiment the possibility of overlap from adjacent nerves for the supply of the deep tissues cannot be discounted, although it should be noted that the response to pinch-prick stimulus was equally evident throughout the entire anaesthetic belt.

EXPERIMENT 2—Rabbit. Laminectomy. Posterior rhizotomy of four right dorsal roots.

Result—Cutaneous anaesthesia about 1 in wide extending obliquely round the body to the upper part of the epigastrium. The rabbit responded to stimulation of a normal area by at once depressing the ears and widely dilating the palpebral aperture. This response was always obtained on stimulating the deep tissues within the anaesthetic belt. It was found that, if this manifestation was evoked, stroking

the animal whilst the stimulus was maintained quietened it again, after which a further increase of pressure was requisite to excite the same response. The additional increased excitation required was now found to be very considerable, the animal remaining perfectly tranquil in the 'rest' attitude, even though great pressure was being exerted, then suddenly it appeared to appreciate this increased stimulus, which was probably due to visceral disturbance such as respiratory embarrassment. Throughout these procedures the animal was counter-supported with a cotton-wool pad, otherwise the slightest displacement would cause alarm.

The experiment shows two distinct sensory responses—(a) An early appreciation when the deep tissues were pinched, a response that was merely characterized by an attitude of 'awareness', (b) The late response, probably from visceral disturbance. The accidental fracture of a rib in the area of anaesthesia was definitely appreciated.

EXPERIMENT 3—Rabbit. Division of three dorsal posterior roots on right side.

Result—Total anaesthesia of skin and deep tissues over a belt $\frac{1}{2}$ in wide, extending obliquely round the body—a result which shows that deep sensation is not retained in every case after dorsal rhizotomy.

The difficulty of stimulating a localized body area with possibly fallacies from visceral responses or through innervation of superficial muscles, decided one to turn to the limbs for a more decisive field, the objective being the section of the total afferent supply to a single member by posterior rhizotomy. This was primarily attempted in connection with the fore-legs, but failed through death from shock always supervening, but in the case of the hind limb the animals withstood the operation more satisfactorily although the average mortality was never less than 28 per cent.

In rabbits the anterior crural nerves in most cases by one large root between the 6th and 7th lumbar vertebrae, and by two smaller roots above this, passing out between the 5th and 6th and the 4th and 5th vertebrae respectively, the uppermost root being very small. The obturator nerves from the 6th and 7th lumbar roots, whilst the sciatic has four large roots from the 6th and 7th lumbar, and the 1st, 2nd, and 3rd sacral.

It will be seen that section of the posterior roots of the last four lumbar nerves and the first two sacral, combined with a transverse section of the spinal contents below the last sacral root to be severed, should eliminate all the usual sensory channels from the hind limbs. This was the procedure usually carried out in the experiments to be described. As an aid to location of the roots the faradic current was occasionally used, although the posterior spine of the blade of the ilium on a level with the first sacral vertebra was an efficient anatomical landmark.

EXPERIMENT 1—Rabbit. Lumbosacral laminectomy, section of 4th, 5th, 6th, and 7th lumbar, and 1st sacral posterior roots, left side.

Result—The animal was considerably shocked. On examination the next day the left leg was found to be completely paralysed. Stimulus applied to plantar and dorsal surfaces of the foot, and extensor and flexor side of the leg, was readily appreciated. On post mortem examination it was impossible to decide whether the lower posterior roots had been severed owing to matting of the tissues. An extensive intrathecal hæmorrhage accounted for the paralysis.

EXPERIMENT 2—Rabbit. Lumbosacral laminectomy. Section of the left 5th, 6th, 7th lumbar, and 1st and 2nd sacral posterior roots, and transverse section of spinal contents below 2nd sacral.

Result—No paralysis of the left leg. Retention of deep sensation on the plantar and dorsal surfaces of the foot and on the flexor and extensor sides of the leg and

thigh Stimulation of the leg evoked firm adduction Sensation was most apparent between the first and second toes and over the sciatic nerve in the thigh The skin was completely insensitive Post-mortem root division confirmed

EXPERIMENT 3—Rabbit Lumbosacral laminectomy Section of the left 4th, 5th, 6th, 7th lumbar, and 1st and 2nd sacral posterior roots, and transverse section of the spinal contents below 2nd sacral

Result—The left foot was completely paralysed, the leg nearly so, and the thigh showed marked paresis The left foot was absolutely anaesthetic to all stimuli Excitation of the leg produced an attitude of 'awareness', the animal turning round to look at the leg on some occasions If its attention were diverted to the opposite side by holding a carrot there, stimulation would make it 'listen', then turn to look at the side stimulated The thigh was also definitely sensitive to severe pinch-prick stimulus The skin was everywhere insensitive Post-mortem root section confirmed

EXPERIMENT 4—Rabbit Division of the left 4th lumbar to 2nd sacral posterior roots, and transverse section of spinal contents below 2nd sacral roots

Result—Total anaesthesia of the left leg Slight paresis in muscles of left thigh

EXPERIMENT 5—Rabbit Division of left 4th lumbar to 2nd sacral posterior roots, and transverse section of spinal contents below 2nd sacral roots

Result—Total anaesthesia of the left leg Paresis of left leg

The foregoing experiments demonstrated that in a certain proportion of cases sensation is retained in the deep structures after extensive posterior rhizotomy whereas in all cases the skin is totally insensitive, results which bear comparison with those following the operation in certain human subjects Again, it will be noted that no sensation was found in that part of a limb if it were paralysed, except in the first experiment These results, when taken generally, indicate ventral root conduction although the possibility of some additional path, such as the abdominal sympathetic conveying stimuli to a level above the root section, is not entirely excluded The two following experiments eliminated this latter possibility—

EXPERIMENT 1—Rabbit Laminectomy Total transverse section of the mid-lumbar spinal cord above the 4th lumbar roots

Result—Complete paralysis and anaesthesia to all stimuli of both hind limbs

EXPERIMENT 2—Rabbit Lumbosacral laminectomy Section of 5th, 6th, 7th lumbar, 1st and 2nd sacral left posterior roots, and division of the spinal contents below the 2nd sacral root There was almost continuous hæmorrhage from the cut laminae, which was controlled by direct pressure, as a result the ventral roots were found to be damaged, and consequently all were finally divided

Result—Complete paralysis and anaesthesia of the affected leg Post-mortem root section confirmed

These two experiments justify the conclusion that when sensation is retained after dorsal rhizotomy, it is mediated by the ventral roots below the 3rd lumbar roots

The next question that presents itself is that of the intraspinal path of these impulses In order to investigate this problem posterior rhizotomy was combined with hemisection of the cord at the cephalic extremity of the wound (*Fig 355*) All testing was carried out the day following operation and on succeeding days The average period of survival was three to four days

EXPERIMENT 1—Rabbit Lumbosacral laminectomy Section of the 4th, 5th, 6th and 7th lumbar, and 1st and 2nd sacral posterior roots, on the left side

Transverse section of spinal contents below the 2nd sacral and right hemisection of the cord at the head end of the wound

Result—Intrathecal hemorrhage paralysed the left leg almost completely. Sensation absolutely lost in the left leg, and responses very weak from the right side

EXPERIMENT 2—Rabbit Lumbosacral laminectomy Section of the 4th, 5th, 6th, 7th lumbar, and 1st and 2nd sacral posterior roots, on the left side Transverse section of spinal contents below the 2nd sacral root, and left hemisection of the cord

Result—Paralysis of left leg, paresis of the right leg Cutaneous sensation lost on the left leg, but deep stimulation, especially of muscle and tendon, produced a definite sensory response Post-mortem root and spinal section confirmed

EXPERIMENT 3—Rabbit Lumbosacral laminectomy Section of the 4th, 5th, 6th, 7th lumbar, and 1st and 2nd sacral posterior roots on the left side Transverse section of the spinal contents below the 2nd sacral root Right hemisection of the spinal cord

Result—Paralysis of right leg, paresis of the left Deep pressure stimuli were readily appreciated in the left leg Post-mortem root and spinal section confirmed

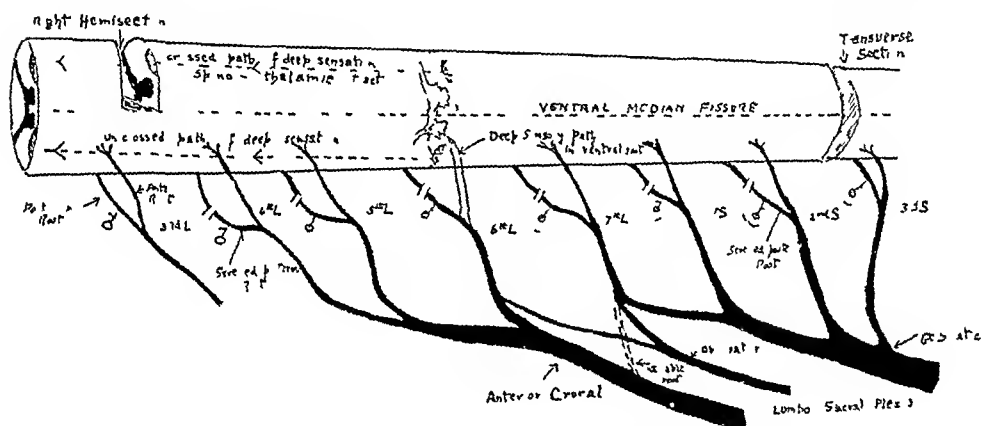


FIG 355.—Diagram of lumbosacral cord showing section of the 4th, 5th, 6th and 7th lumbar and 1st and 2nd sacral posterior roots together with transverse section of the spinal cord below the 2nd sacral roots, and right hemisection at the cephalic end of the wound

EXPERIMENT 4—Rabbit Lumbosacral laminectomy Section of the left 4th, 5th, 6th, 7th lumbar, and 1st and 2nd sacral posterior roots Left hemisection of the cord Much hemorrhage

Result—Complete paralysis and anaesthesia of both hind limbs

EXPERIMENT 5—In the animal of Experiment No. 2 the right posterior column was divided on a level with the left, hemisection two days after the first operation

Result—Sensation in muscle and tendon was still distinctly appreciated proving that the sensory impulses from these structures were traversing the crossed antero lateral column, presumably in the spinothalamic tract Post-mortem root and spinal section confirmed

EXPERIMENT 6—Rabbit Left posterior rhizotomy, hemisection of the cord, and division of the right posterior column as in Experiment No. 5

Result—Retention of deep sensitivity in the left leg Right leg anaesthetic Post-mortem root and spinal section confirmed

EXPERIMENT 7—Rabbit Lumbosacral laminectomy, posterior rhizotomy of the left 4th, 5th, 6th, 7th lumbar, and 1st and 2nd sacral roots Section of spinal

contents below 2nd sacral Left hemisection at cephalic end of the wound Section of right posterior column at the same level

Result—Severe pinch-prick stimulus applied to the point of the heel, the plantar surface of the foot, the flexor muscles of the leg and thigh, or pressure on the tibia, produced a definite sensory response half an hour after recovery from the anæsthetic Examination on the day following showed complete loss of all sensation in the same limb

EXPERIMENT 8—Rabbit Lumbosacral laminectomy Posterior rhizotomy of the 4th, 5th, 6th, 7th lumbar, and 1st and 2nd sacral roots, on the left Section of spinal contents below the 2nd sacral Left hemisection and division of the right anterolateral column

Result—Total loss of sensation in the left leg

EXPERIMENT 9—Rabbit Lumbosacral laminectomy Section of 4th, 5th, 6th, 7th lumbar, and 1st and 2nd sacral posterior roots, on the right side Right hemisection of the cord, division of the left anterolateral column at the same level and transverse section of all spinal contents below the 2nd sacral nerve

Result—Complete anæsthesia of both legs

To summarize briefly the results of these experiments, it has been shown that —

1 Complete transverse section of the lumbar cord above the 4th root abolishes sensation of the corresponding leg

2 Section of all the roots of the lumbosacral plexus abolishes all sensation of the corresponding limb

3 Section of the 4th, 5th, 6th, 7th lumbar, and 1st and 2nd sacral posterior roots, with transverse section of all below the 2nd sacral roots, results in retention of deep sensation in all parts of the corresponding limb, more especially in the leg and thigh in a certain proportion of cases

4 Paralysis of any segment of a limb under conditions No 3 removes the residual sensation

5 The retained sensation gives rise to an attitude of 'awareness' rather than pain, although in one or two cases there appeared to be pain on very strong stimulation, but the response might be due to fear

6 Section of the contralateral or the homolateral half of the cord after rhizotomy as above, does not abolish the residual sensation

7 Section of the homolateral or the contralateral side of the cord, with rhizotomy and division of the opposite posterior columns, does not abolish the residual sensation

8 Section of the contralateral or the homolateral side of the cord, with rhizotomy and division of the opposite anterolateral column entirely eradicates all residual sensation

9 There were four negative cases where posterior rhizotomy abolished deep sensation

10 The operative mortality averaged 28 per cent in all experiments

Certain results of posterior rhizotomy as described by Tiendelenburg in 1906 throw a corroborative light on the foregoing experiments Working on pigeons he noticed that when the dorsal roots were severed in those segments supplying the leg muscles, the tone of the latter was abolished, a destruction of similar roots in association with the wing muscles did not result in loss of tone, the wings were retained in approximately their normal

position of flexion. Further, destruction of the labyrinth or removal of the brain did not abolish this tone flexion. Baghoni, in 1907, explained the results as being brought about by a reflex excited through the leg muscles, it would appear equally explainable on the grounds of afferent fibres in the ventral roots mediating the sensory side of the reflex, *are whose afferent side* was also conveyed by the same, the phenomenon being dependent on a localized spinal reflex. Meizbacher noted similar facts in relation to the tone of the tail muscles in dogs.

EVIDENCE AS TO AN ENDONEURAL AFFERENT SYSTEM AS SHOWN BY THE CRANIAL NERVES

Many important facts in connection with these nerves have been observed that throw considerable light on the question of an endoneural afferent system, which makes then discussion a vital point in the chain of evidence.

In the first place, the trigeminal, as the great sensory path of the face may be considered. Ciyer, of Philadelphia, reported three cases of neuralgic pain in the floor of the mouth which were studied by Ivy and Johnson. The pain was felt on the inner side of the lower jaw. Section of the mandibular division of the 5th nerve below the origin of its mylohyoid branch failed to relieve this condition, whereas section of the same nerve above this branch cured the pain, which was interpreted as showing that the motor mylohyoid nerve contains afferent fibres from the muscle, pain being seated in that structure. The same investigators studied a case of Spiller's where the latter had performed gasserianectomy for trigeminal neuralgia, in which they found complete retention of deep pressure sensitivity in the 5th nerve area, *again* pointing to the motor root of the 5th or the facial nerve as the conductor of deep sensation.

A case reported by T. H. Weisenberg and cited by L. Kidd introduces excellent clinical evidence to show that the central end of a severed 5th nerve possesses undegenerated afferent fibres. The patient suffered from typical trigeminal neuralgia in the distribution of the superior maxillary division which was not relieved by five peripheral operations. Finally, gasserianectomy was performed, both motor and sensory roots were divided. Relief was only temporary, within a few months (cf. spinal cases) the pain returned in the lower part of the face, throat, and tongue, accompanied by paræsthesia of the oral cavity. The patient subsequently died, and at the autopsy a tumour of the cerebellopontine angle was discovered. This lay immediately on the sensory and motor roots of the 5th nerve. Microscopical examination showed that the cells of the mesencephalic root were normal, whilst section of the nerve showed regeneration in the motor root, with distinct myelin-sheathed axis cylinders amongst the numerous degenerated fibres in the sensory root. Kidd interprets this case as showing that the mesencephalic root is sensory, consequently gasserianectomy would cause degeneration of all the sensory fibres except those arising from this nucleus (that of the mesencephalic root) which pass out either in the sensory or the motor roots of the 5th. With respect to the latter, Aldien Turner, in 1894, found in an eight-month human foetus that

all the medullated fibres of the mesencephalic root traversed the motor division. Thus the tumour in Weisenberg's case would stimulate the undegenerated afferents, the irritation being referred by the cortex to the peripheral distribution.

This interpretation of the cells of the locus caeruleus and the tectum mesencephalic which gives rise to the mesencephalic root is supported from other considerations. These cells develop from the dorsal lamina of His, which is not known to give rise to any motor cells. Johnston compares them with the dorsal cells found in the spinal cord of fishes and amphibians, which belong to the same category as the peripheral ganglion cells, whilst they may also be compared with the ganglion cells of the dorsal nerves in the amphioxus, many of which lie within the central nerve cord. All of which points indicate the afferent function of this root of the 5th nerve.

Miss Tozer and Sherrington, in a series of experiments on the ocular nerves, found that section of the 3rd, 4th and 6th at their central origin caused a disappearance in the eye muscles not only of the motor end plates, but also of the sensorial terminals. Sherrington had previously shown in 1898 that these sensory fibres in the ocular muscle do not degenerate after gasserianectomy, proving that they possess trophic cells situated either in the central nervous system or amongst the root fibres, the afferent axons of which run in association with the motor fibres.

The presence of afferent fibres in the facial nerve of animals was long ago shown by the stimulation experiments of Bernard, where irritation of the central end of the severed nerve resulted in "une sensibilité évidente" or "le bout central etait très sensible". In 1899 Aldien Turner cut intracranially this nerve in *Macacus rhesus* for Edgeworth, who examined the branch to the posterior belly of the digastric, which showed complete degeneration with the exception of three medullated fibres all under 4μ in diameter, on the other hand, the main trunk of the facial peripheral to this branch showed non-degenerated fibres from 11 to 12μ in diameter. The larger fibres may be compared with those which Gaskell and Edgeworth describe in association with the spinal roots, and which average about 7 to 9μ in diameter in the dog, and which they consider sensory in function. Their presence in the facial is made clearer in the light of Amabilino's findings—that section of the chorda tympani produces degeneration in only two-fifths of the cells in the geniculate ganglion.

Turning to the clinical side, Kidd states that in his experience 75 per cent of cases of facial palsy exhibit sensory disturbance. Lastly, the evidence of gasserianectomy shows that vague deep sensation is retained in many cases on strong compression of the facial muscles against the bone, in addition to the case of Spiller's already mentioned, whilst the remarkable diminution of the anæsthetic field following this operation after a lapse of years, must be borne in mind.

Finally the case for the dorsal vagoglossopharyngeal nucleus may be cited. Hudovcic found changes in the cells of this nucleus in a case of carcinoma of the œsophagus, illustrating the 'distance reaction' following the reception of afferent irritant stimuli by the cells which would not occur if a synapse were interpolated on the path between œsophagus and dorsal nucleus, from

which it follows that the afferent trophic cells of the fibres concerned may be endoneurial in situation

From this conspectus of the evidence derivable from the cranial nerves bearing on the question of an endoneurial afferent system, three general inferences may be made —

1 That the 5th cranial nerve contains afferent fibres possessing centrally situated trophic cells, the axons of which run partly with the motor fibres

2 That the same is possibly true of the dorsal vagoglossopharyngeal nucleus, whilst the facial nerve is probably an example of the association of muscular afferent and the corresponding motor fibres

3 That sensation mediated by these afferent nerves from muscle is very difficult to elicit by ordinary stimulus

4 That the 3rd, 4th and 6th ocular nerves contain afferent muscle fibres associated with the motor supply which possess trophic cells in the central nervous system or in the nerve-roots

CONCLUSIONS AS TO SENSORY CONDUCTION IN VENTRAL ROOTS

In concluding this section bearing on the mediation of afferent stimuli by the anterior roots, the evidence from the different sources may be summarized

1 From the experimental side, despite the difficulties of interpreting sensory responses in animals, and allowing for fallacies and negative results there would appear to be reasonable grounds for the belief that rabbits receive afferent impulses from the deep tissues, such as fascia, muscle, tendon, and bone, by the ventral roots. The work of Claude Bernard on anterior-root sensibility demonstrated that sensory effects follow stimulation of the same, of which it is possible that the minor sensory responses are due to centripetal fibres in these structures. Again, from the experimental side the results of Tiendelenburg's experiments on pigeons probably depend on ventral-root sensory fibres completing the tonic reflex arc

2 From the clinical side, the cases of dorsal rhizotomy for tabes crises and cervicodorsal rhizotomies for brachial neuralgias followed by retention of deep sensation, and also those cases which show a rapid return of sensation after root resection, emphatically point to the existence of a sensory channel in addition to that through the posterior roots. Similarly, from the subjective standpoint the return of pain in many of these cases indicates a like proposition. Finally, the case of rhizotomy for tabes with ventral-root section already described, which showed complete anaesthesia and cure, taken in conjunction with a successful case of cervicodorsal rhizotomy of both roots for intractable stump neuralgia, greatly strengthens the sensory ventral-root hypothesis

3 The third field, which supplies us with strong collateral evidence, is that of the cranial nerves, where it was shown that there was reason to believe that an endoneurial afferent system exists, centripetal impulses from muscle being conveyed by axons possessing centrally situated trophic cells, the same entering the nervous system in association with the motor fibres

From these three general lines of evidence we feel justified in concluding that the anterior spinal roots mediate afferent impulses in normal individuals from deep tissues

THE CONDUCTING MECHANISM

The nervous pathways by which these pain stimuli are conveyed to the spinal cord must now be discussed more especially with reference to the physiological types of fibres involved.

For convenience of analysis the varieties of pain will be considered in three broadly defined groups according to whether there is (1) *Vascular dilatation* (2) *Vascular constriction* or (3) *Neither of these phenomena*. But it must be remembered that in actual practice the same case may exhibit all three varieties at different stages or combinations of these effects.

Group 1. The first group comprises those cases that show the typical causalgic syndrome. Pain of a burning, throbbing, prickling or bursting character is complained of—persistent in form and accompanied by dilatation of the blood vessels with consequent erythema and slight swelling of the affected part.

As pointed out by Professor J. S. B. Stopford (in a paper in the *Lancet* Aug. 11, 1917 on a series of cases of thermalgia) vasomotor disturbance of a dilator type is the principal pain factor in these cases. At the same time he suggests that the vasodilator phenomena are reflex in character—otherwise one would have to suppose a selective action of the intramedullary sclerosis on the depressor fibres which would be difficult to understand whilst the same investigator makes the supposition that irritation would produce a depressor effect as a protective and defensive mechanism.

If these vasodilator phenomena are dependent on a depressor reflex, what are the components of the reflex arc?

To comprehend the subject thoroughly it is necessary to turn to the surgical procedures that have been practised for the condition. Local resection of the scar tissue of the partially divided nerves with secondary suture completely cured many of these cases due to gunshot injury. Microscopical examination of the resected nerves commonly showed extensive intramedullary fibrosis. From these results we might conclude that the primary form of irritation is in the injured nerve, hence resection of the same cures the condition. The other procedure carried out by R. Lenke of Lyons is peri-articular sympathectomy. In a series of cases of causalgia this operation cured five and improved two the remaining two being failures—whilst Platon met with success from this *modus operandi* in 75 per cent of his cases—results which show that roughly three-quarters of these causalgic neuralgias are benefited by sympathectomy.

If the sensory path to the central nervous system by which the throbbing pains are perceived lay in ordinary sensory fibres peri-articular sympathectomy could not possibly interfere with their conduction. Thus if the artery were denuded, the irritation from the nerve lesion would still be perceived by the sensory fibres in the mixed nerve which terminate in cutaneous and deep receptors.

This raises the question as to whether vascular dilatation is the essential cause of the burning pain, or is this an independent and superadded feature to the vascular depression? That the latter is indicated is shown by the results of peri-articular sympathectomy—a procedure which first results in

arterial spasm, and secondly in considerable vascular dilatation and hyperæmia of the skin. At the same time the typical pain is cured.

Again, in some cases of causalgia it is well recognized that the case may change in respect to the vascular symptoms: signs of constriction of the vessels following after prolonged dilatation, nevertheless in these cases pain still persists losing only its thermal character, that is, the burning sensation. The course of the peri-arterial fibres which convey the pain sense, above described, was shown to a certain extent by an experiment which Professor Stopford kindly performed for me. The two possible channels by which such fibres might conceivably reach their destination are either through a mixed nerve passing into the peri-arterial plexus at intervals throughout the course of nerve and artery down the limb, or by joining the blood-vessel soon after leaving their origin and following its entire length. In the experiment mentioned, the sciatic nerve was divided in the gluteal region of a rabbit. Testing for sensation demonstrated its presence in the foot especially on the dorsum between the first and second toes. The internal saphenous nerve was now severed, and the foot was found to be totally anæsthetic to all forms of stimulation, showing that there were no afferent fibres following, for example, the dorsalis pedis artery and proceeding up the vessel to a proximal source independent of the main nerve, thereby suggesting that they probably arise at intervals from the mixed nerve to join the artery similarly to the supply of the phalangeal joints by the digital nerves.

From this it will be seen that section of the sympathetic on an artery at the proximal end of a limb for a peripheral disturbance would not interrupt stimuli travelling the lower arterial twigs of the mixed nerve, which would account for the cases of failure after this operation.

Returning to the question of reflex origin of the vascular phenomena, we have to consider the spinal roots by which the stimuli reach the central nervous system. In view of Bayliss's work upon the condition of vasodilator fibres in the posterior roots, the latter suggest themselves both on this consideration and as then being general conduits of centripetal impulses. It has been shown that the pain is distinct from the vascular dilatation, and that both are probably mediated by the peri-arterial plexuses. A case of Sir William Thorburn's exemplified very clearly this difference between pain and dilatation at the same time indicating the path of approach to the spinal cord of the pain impulses —

The patient sustained a bullet wound in 1914, and examination in 1915 showed a partial paralysis of the upper limb, accompanied by patchy analgesia and hypoaesthesia to cotton-wool touch, in addition to these objective signs he complained of a tingling burning pain localized to the palm of the hand and to the centre of the forearm for about a third of the distance to the elbow-joint. At the first operation the inner side of the median and the ulnar nerves were sutured. The causalgia persisted, and at a second operation neurolysis was performed, which greatly aggravated the condition. On re-examination in 1921, trophic changes were evident, the skin of the hand was thin and glossy, the nails long and curved, whilst the intrinsic muscles of the hand showed extreme wasting. About this period the thermal symptoms—that is to say, the burning sensation and the vasodilatation—subsided, the pain persisting as a constant gnawing ache, whilst the hand became withered in appearance. Posterior rhizotomy of the 6th cervical to the 1st dorsal roots was performed, and they were seen to be clearly divided. The day following operation there was

in exacerbation of pain which subsided on the second day after which the former pain (aching) returned in the same area of the hand and is still severe at the present day.

In this case it is clear that all afferent paths via the dorsal roots have been interrupted from the affected areas leaving the ventral roots as the possible channel for sensory conduction of the pain stimuli. (The question of intraspinal irritation is discussed later.) Were the earlier vasodilatory phenomena dependent on a reflex the afferent side of which was mediated by the ventral roots? Do the persistent pain impulses still traverse this channel? These are the pertinent questions suggested by this case.

Gaskell has shown that stimulation of the anterior roots of the sciatic plexus causes an increased blood flow through the muscles of the leg indicating that depressor fibres exist in these roots. The presence of depressor fibres in the ventral cervical roots is therefore a possibility. Bayliss has shown that the efferent depressor stimuli traverse the posterior roots, the impulses being conducted by fibres possessing trophic cells in the posterior root ganglia and consequently indistinguishable anatomically from the normal sensory fibres, a fact which suggests that these efferent impulses are conducted antidromically to the ordinary stimuli in the posterior root fibres. This possibility is further shown by the effects of mustard oil applied to the skin, the stimuli from the oil causing reflex vasodilatation, an effect which is still produced after posterior root section until degeneration has spread to the peripheral parts of the fibres involving the collateral branches to the blood-vessels in association with the area of skin supplied by the affected fibre. The stimuli in this case must pass in an efferent direction up the sensory fibre and down the nearest collateral to the blood-vessels. Since the mediation of depressor impulses by afferent fibres is known to exist, it seems reasonable to suppose that the converse might equally pertain, namely the conduction of sensory stimuli by depressor efferents traversing the ventral roots, especially when we consider that the fibres conveying these causalgic pains are associated with the nerves to the blood-vessels, as already shown.

The failure of posterior rhizotomy then becomes easily comprehensible. Even supposing the vascular dilatation observed in these cases to be the result of an axon reflex, or again of a reflex produced through the undisturbed posterior root ganglia, there still remains to be explained the path of the pain sensation to the spinal cord when the dorsal roots have been severed with consequent complete degeneration in the ascending tracts of their fibres.

Another very interesting case which may be considered at this juncture is one reported by Professor Stopford —

The patient was wounded in 1918 by a bullet in the neck, resulting in complete loss of power in the left arm, and within a week in the onset of severe burning pain in the thumb. Examination in July of the same year revealed complete paralysis of spinati, with great paresis of the deltoid, biceps, brachialis internus, triceps, and supinator longus, but no objective sensory disturbance could be found; on the other hand, there was severe burning pain in the thumb, aggravated by heat, all of which symptoms abated in time.

In this case the complete absence of sensory disturbance would seem to negative any injury to the sensory root fibres, the subjective disturbance, of

a typically causalgic type, being associated with the motor lesion again strongly suggesting the irritation of afferent fibres in these roots, which also resulted in depressor effects on the blood-vessels

It is worth recalling at this juncture that the sensory end organs such as the Pacinian bodies and those of Ruffini possess very vascular networks. From the results given above, there appears to be a strong suggestion of some relationship between sensation and vascular dilatation which is independent of the usual sensory nerves, and at the same time there is an independence between the sensory element and mere dilatation of the vessels, the one being capable of existence without its complement—the two together, vasodilatation and irritation of afferent fibres, producing the typical burning pain, but without the depressor action, pain is only gnawing or aching in character. As for the cause of the change in some of the causalgias to vasoconstriction Professor Stopford has suggested that it is due to local trophic disturbances in the blood-vessels causing proliferation of the intima resulting in occlusion or partial occlusion of the vessels. The association between sensory receptors and vasodilatation is further illustrated by the results of a series of experiments I carried out on the human subject, from which one made the general inference that stimulation of a mixed nerve so as to produce vascular depression also results in diminution of the threshold stimulus in both deep and cutaneous receptors, a result which is independent of passive flushing due to the dilatation of the blood-vessels in the sensory organs, whilst at the same time it is not attributable to simple hyperæsthesia of ordinary afferent fibres—suggesting that the nerves that convey depressor impulses also augment sensory receptivity, which when applied to these cases explains the relation of peri-arterial sympathectomy in the alleviation of pain.

Group 2—In the second group will be discussed the nervous paths of those forms of pain which are associated with pressor effects in the vascular system, and other signs of sympathetic irritation, such as persistent hyperidrosis of the painful area, or rapid rise of blood-pressure concomitant with a pain crisis.

This group may be subdivided into three distinct types: (a) Pains of a lightning or stabbing character, (b) Pains described as gnawing, aching, or burning, (c) Gripping, twisting or vice like pain, generally occurring only during acute crises. The distinctions of this group from the former are the entire absence of vasodilator signs and thermalgic character of the pain, on the other hand, the areas affected frequently show vasoconstriction, or if these symptoms are intermittent, they generally occur during an acute exacerbation. Lastly, at the risk of repetition, it must be remembered that these several varieties may occur together or independently in the same individual.

a The lightning stabbing form of pain so often seen accompanying tabetic lesions is generally cured by section of the posterior spinal roots, which proves that its mediation is dependent on afferent fibres traversing the general sensory path. Thus in a case of Hey Groves's in which there was persistent neuralgia of this type in the legs, the left more especially posterior rhizotomy, although failing to cure the pain, changed its character, which after operation was described by the patient as being like a gnawing sensation, at the same

time its severity was somewhat mitigated. Likewise, I have noted that the lightning radiating pain in the body wall which occurs in gastric crises is abolished by the root resection.

b The second variety which is gnawing in character frequently accompanies the lightning type persisting between the exacerbations of the latter. In addition the peculiarity of its situation is sometimes recognized by the patient who states that it feels as if it were in the 'flesh' others describe it as being in the 'bones' discriminating it from a superficial hyperaesthesia. This situation of the pain was clearly shown in two of Thorburn's cases (takes dorsalis crises) where deep sensibility was retained after rhizotomy. In both the somatic pain complained of was of a dull gnawing character located in the deep tissues of the abdominal wall clearly differentiated from a deeper intra-abdominal pain which was only experienced during a crisis and equally differentiated from the skin by the patient who always described it as being a 'muscular sensation'. In its severer form the onset of this pain was accompanied by marked increase of sensitivity of the deep tissue to light pressure stimuli. This variety of pain merges during an acute crisis by imperceptible degrees into

c The third type that which is characterized by a gripping or twisting sensation. One of the two cases referred to described the deep sensation as a feeling as if the muscles were being tightly twisted, a vice-like grip was also complained of.

Accompanying these subjective sensations there are frequently seen signs of sympathetic activity such as vasoconstriction and rapid rise of the blood-pressure—in one of the above cases from 130 mm Hg to 175 mm Hg—whilst in the same patient reduction of the blood-pressure by trimeth tablets and amyl nitrite to 55 mm Hg abolished this symptom. Another fact pointing to the sympathetic associations of this type of pain is its excitation by adrenalin injection, the subcutaneous injection of this drug (10 mm 1-1000 solution) producing an acute crisis in one of the takes cases whilst a case reported by Barling showed an increased pulse-rate to 120 per minute.

It has been shown that this dull type of pain is principally located in the deep structures especially in muscle. The gripping character occasionally assumed by the pain is essentially characteristic of muscular disturbance whether splanchnic or somatic and does not feature in cutaneous hyperaesthesias or in bone pains. All results of experimentation go to show that muscle sense is most difficult to evoke by ordinary stimuli, but when produced by pathological irritation it is capable of giving rise to most exquisite pain, as, for example, in an intestinal colic or a cramp of the calf muscles.

As already stated, the muscle afferents from the eye are not affected by gasserianectomy, nevertheless the eye may be excised after the latter operation without any sensation being felt by the patient (*see* Morrison Davies), although Sherrington has stimulated the inferior oblique muscle of a cat's eye with consequent pricking of the ears and movement of the opposite eye, as if it appreciated some sensation. Again, the results of sensory experiments on the alimentary canal show that only slight sensation is produced by the strongest stretching or pinching of the muscle coat of the bowel which is totally unresponsive to cutting stimuli, though a sensation of definite

discomfort may be elicited by inflation of a localized segment (e.g., colostomy). Myological sense may be said to possess a high potential which can only be evoked by a morbid process.

We have, therefore, to investigate the nerve path of these painful muscle stimuli. If cervicodorsal posterior rhizotomy alone failed, it would be reasonable to presume that the afferent path of the stimuli lay through the sympathetic connection traversing the first dorsal ganglia to the lateral chain, and thence via the posterior and lower dorsal roots to the cord. The failure, however, of extensive and even bilateral posterior rhizotomy of the dorsal roots for epigastric pains, as in tabes, where there is no intricacy of the sympathetic path as pertains in their distribution to the upper limb eliminates this possibility, and indicates once more the ventral roots as the mediators of the sensory stimuli.

What structures are there to be found in muscle which can be definitely associated with the sympathetic system, which communicate with the spinal cord by the ventral roots, and whose function has not been proved to be either motor or proprioceptive? The terminals described by Boeke and Agduhi fulfil these conditions. They consist of non-myelinated fibres terminating in cluster-like ramifications beneath the sarcolemma, often in close apposition to or even in conjunction with, the motor end-plates, whilst Agduhi has observed them on the fibres in the muscle spindles. Thus from their situation and histological appearance the evidence as to function is equivocal. Their sympathetic nature has been definitely demonstrated by section of the anterior and posterior roots of the 5th, 6th, 7th, 8th cervical and the 1st dorsal nerves, and extirpation of the posterior root ganglia, which does not produce degeneration of these endings in the interosseal muscles similar to all the myelinated endings, whilst, on the other hand, removal of the stellate ganglia results in their degeneration. Similarly, section of anterior and posterior roots with excision of their ganglion in the dorsal region also leave untouched these terminals in the intercostal muscles showing that the trophic cells of the peripheral fibres must be in the sympathetic ganglia of the lateral chain, the spinal connection being in all probability through the ventral roots by the white rami communicantes.

It has been suggested that their function is the mediation of trophic stimuli, or to assist in the preservation of muscle tone. As to the latter, the evidence appears contradictory, although on this theory the results of Trendelenburg's experiments are quite intelligible, these sympathetic fibres acting as afferents in the tonic reflex arc.

In one of the tabes cases previously cited, where an experimental injection of adrenalin was administered, the rigidity of the skeletal muscles in the painful area was so very pronounced a feature as to produce opisthonotus accompanied by a pain in the posterior muscles of the spinal column described as being like the 'grip of a vice', which passed off as the muscular contraction subsided. A similar type of rigidity has been noted to accompany the 'stupeur arterielle' of Leiche. This observer has seen motor contraction diminish and disappear when 'acting on the peri-arterial sympathetics', he also mentions a case of Clovis Vincent's where even deep general narcosis and section of the main nerves in a case of painful stump failed to relieve

painful muscular rigidity whereas sympathectomy immediately relieved both symptoms which had not reappeared after forty days. He states that he and Hertz have seen sympathectomy greatly improve eighteen cases of hypertonic contraction which subsided the day following operation.

These observations emphatically point to the deep-seated pain of a definitely gnawing character often associated with muscle rigidity as being mediated by the sympathetic supply to deep tissues especially the muscles. In this connection it is interesting to mention some observations recorded by Beer on a case where he divided the left anterolateral tract of the spinal cord for a neoplasm causing right-sided neuralgia in the leg. After operation which abolished pain he noticed that there was diminution to pressure sensibility of the muscles on the right side which was associated with complete analgesia in the same area suggesting that the pain in this case was mediated by tracks possibly in part association with deep pressure impulses. It will be recalled that in the rabbit experiments the deep retained sensation was found to be conducted principally by the anterolateral tracts evidently associated with the impulses of pain.

Group 3—In the third and last group are placed those pains which are not accompanied by any marked vasomotor disturbances. The operative results suggest that some of these cases may be due to irritation solely confined to afferent fibres traversing the posterior roots, consequently section of the root corresponding to the affected area cures the condition. Two patients of Bennett's and another of Horsley's exemplify the operative results in these cases. They are not, however, typical of the large majority of neuralgic cases that fail to subside with medicinal treatment or peripheral operations.

The close similarity of many of these pain cases to those associated with definite sympathetic disturbance suggests that they are dependent upon a similar nervous channel. The deep tissue seat of some and the failure of posterior root section in others both indicate the affinity between the simple forms and those with obvious vasomotor symptoms.

Finally it will be seen that a diffuse lesion such as occurs in tabes may irritate more than one type of nerve path in the same individual, consequently burning pain may be felt in one area, whilst aching and gripping sensations occur in another in association with vasoconstriction.

In concluding this section on the pain conduction, the evidence showing that the sympathetic system probably mediates these stimuli especially from muscle may be reviewed, namely that—

- 1 Pain in these cases is principally seated in deep tissues
- 2 The rigidity in the tabes case clearly points to a muscular origin of pain
- 3 Sweating, vasoconstriction, raised blood-pressure during pain crises, rigidity of muscle in a pain crisis, tachycardia and adrenergic hypersensitivity also indicated an irritability of the sympathetic system
- 4 Sympathectomy abolishes painful muscle spasm
- 5 The end organs of Boeke supply the necessary sympathetic terminals for the location of these phenomena in muscle in association with that system

and the central connections of these end organs explains the many partial or complete failures of posterior rhizotomy

INTRASPINAL IRRITATION

The last possible cause of pain in cases where posterior rhizotomy has failed is intraspinal irritation

It is reasonably conceivable that the effects of a rachioiditis would not be confined to the spinal roots but extend to the columns of the cord, in such cases the intraspinal irritation might bring about the failure of the extraspinal operation. Secondary sclerosis might produce thermalgic pain, as occasionally it does in cases of disseminated sclerosis. On the other hand it will be remembered that the majority of these neuralgias exhibit a strictly localized distribution within a definite area, generally involving one or two spinal segments which, if we are to suppose intraspinal irritation, would necessitate an irritant stimulus confined to these fibres in association with the affected area. If the posterior roots concerned are severed, then the irritated fibres will completely degenerate, whilst the division of roots above and below those affected would entail complete degeneration of all neighbouring axons, from this one might reasonably expect relief of pain after the degeneration was complete—a result infrequently obtained. Such changes would not remove the source of irritation, for example, an area of chronic inflammation which would progress beyond its previous limits so as to involve normal tracts, which would result in a return of pain after a varying interval—a development that frequently occurs, but with this important difference—pain returns in the old area in most cases, not in neighbouring and healthy area, which would be the case if fresh axons were involved.

Lastly, the results of section of the anterolateral column for widely divergent cases of intractable pain strongly discountenance a spinal source of irritation—they will be reviewed in the next section.

THE SURGICAL INDICATIONS

The ideal procedure would aim at the complete interruption of all nervous pathways conducting irritant stimuli to the brain, but this would depend upon whether the source of the irritant is situated in the peripheral nerves in the spinal tracts, or in the higher cerebral centres. If the lesion were in the first named, obliteration of its channel of conduction ought to be possible. If in the spinal column, it is evident that a localized lesion anywhere below the origin of the roots of the phrenic nerve could be cut off from the higher centres by section of the tract affected, but, on the other hand, a diffuse lesion involving an entire sensory tract up to the brain stem could not be treated surgically without grave danger whilst a purely cerebral source of irritation would be without the province of surgery.

From the general results of operative treatment for these pain conditions and then clinical history, only a very small minority show a definite psychological factor. On the whole, the source of irritation would appear to be in the peripheral nerves whilst the question of intraspinal stimulation has been

considered in the last section where an attempt was made to show that relapse after rhizotomy from a lesion in this situation is improbable, at least after any considerable interval

Accepting for the present the principle that peripheral irritation is the main factor in the majority of these cases then by section of spinal roots we should be able to interrupt the afferent impulses, the question being which roots to sever

It has been shown in connection with neuralgias of the brachial distribution that the pathways affected probably depend on the type of manifestations, pain of a thermalgic type associated with the depressor effects being mediated by dorsal and ventral roots but having no accessory path by the inferior cervical and first dorsal ganglia. In these cases rhizotomy of both ventral and dorsal roots would have to be practised in order completely to sever the afferent channel. The procedure would only be admissible for cases of causalgic neuralgia in post-operative stumps when the resulting paralysis would not be of any consequence and as shown by past work would relieve the motor spasm sometimes found to accompany the pain

Again in connection with the pain in the body area, we have shown that unilateral rhizotomy of both roots of the mid-dorsal segments is not attended by any respiratory embarrassment from the resulting paralysis of the intercostal muscles, although the after-effects would be dubious if the same procedure were performed bilaterally. In a strictly unilateral pain as in Thorburn's case, involving the mid-dorsal segments one might reasonably consider anterior and posterior rhizotomy. On the other hand, the great difficulty in connection with root section is to ascertain that all the roots to the affected area of the cord have been severed, a small resection frequently failing despite the previous localization of the symptoms, although this was probably due in the past to the ventral root mediation. Also the resection of many roots necessitates considerable exposure of the cord, with attendant shock

Lastly, cases of very localized pain in peripheral areas occasionally yield to section of the roots of the area concerned. Here again there is a great difficulty in knowing whether the neuralgia purely affects the ordinary dorsal root fibres— an uncertainty which renders a localized rhizotomy useless in most cases

In concluding the case for rhizotomy we have to weigh the following facts —

- 1 In cases of stump neuralgia of the upper or lower limbs all ventral and dorsal roots should be severed if the prognosis is to be at all favourable in all cases. This procedure will abolish intractable stump neuralgia of a thermalgic type, but there may be a residual pain due to sympathetic mediation, in which case, if the opportunity presents, where there has been a double cervicodorsal rhizotomy the extirpation of the last cervical and the first dorsal sympathetic ganglia should be considered

- 2 Posterior rhizotomy is occasionally successful for limb neuralgias but the prognosis is completely uncertain

- 3 In only rare cases is a localized rhizotomy for localized pain successful.

- 4 In tabes cases the considerable proportion of successes after posterior root section justify the operation in localized unilateral cases

5 This should be accompanied by anterior rhizotomy

6 The great disadvantage is the considerable exposure of the cord necessary for extensive root section, with consequent shock

Turning to the second situation, where the pain stimuli may be intercepted, we have to consider the anterolateral column of the spinal cord. It has been shown that probably all pain impulses cross in the cord and ascend in the spinothalamic tract of the anterolateral column, therefore section of the same should completely intercept all such stimuli, providing the section is made above the lesion. We may briefly review the results of this operation. Spiller and Martin performed it on a man suffering from great pain in the lower limbs, the result of inoperable tumour of the spinal cord. Both tracts were severed with great relief from all the former pain, although he still had slight discomfort at times. The possibility of a few fibres conveying the stimuli in the posterior columns must be admitted, or the incomplete severance of the tracts. Foster by this operation cured a case where dorsal rhizotomy had failed to abolish pain.

Beer in 1913 sectioned the left column for pain in the right leg secondary to neoplasm, with complete relief of the symptoms. Souttar cut the right column for painful gastric crises of tabes. The patient suffered from intense gastric crises, accompanied by pain in the left leg and left side of the body with burning pain in the shoulder, and intense headache. The operation was performed at the interval between the 1st and 2nd dorsal roots, and resulted in complete abolition of pain with crossed analgesia of the left side of the body. The only relapse was a painless attack of vomiting. Lastly, I hear that a case of causalgia has been successfully treated by this method.

These results, coming from widely different sources, clearly bear out the principle of peripheral irritation, at the same time illustrating the efficiency of spinal section. The advantage of the procedure over rhizotomy is three-fold. In the first place a very much smaller exposure is necessitated, and in the second place the pain fibres are concentrated within a very small area and all afferent fibres mediating pain impulses can be severed with reasonable certainty. Finally, the operation does not involve paralysis if the crossed pyramidal tract be avoided—a sequel which must infallibly follow dual rhizotomy. All these features, we conclude, make this the operation of election in all cases of intractable neuralgia, whether in limb or body areas.

The only disadvantage would appear to be the delicacy of the procedure and the danger of paralysis, although even if the latter mishap should follow, as in Beer's case, the great sensory relief obtained far outweighs the motor loss.

My best thanks are due to the Royal Society for a grant which has enabled the experimental work to be carried out, to Mr E. D. Telford, F.R.C.S. for reading the MS. and for much helpful criticism, to Dr B. A. McSwiney for valuable assistance with regard to the operative work, and to Professor A. V. Hill and Professor Rapee for kindly allowing the experimental work to be conducted in the Physiological Department of the Victoria University Medical School.

RHIZOTOMY FOR INTRACTABLE PAIN

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**THE BACTERIOLOGICAL AND PATHOLOGICAL EXAMINATION
OF THE VERMIFORM APPENDIX IN THE
FIRST THIRTY HOURS OF ACUTE APPENDICITIS
WITH SPECIAL REFERENCE TO THE PRESENCE OF 'FATS' IN
THE WALL OF THE APPENDIX AND LYMPHOID TISSUE**

By LEONARD S DUDGEON AND P H MITCHNER, LONDON

The appendix was removed in twenty-five cases in the early stages of the acute disease. From the clinical history the maximum period of illness was within thirty hours. It was believed that this stage of the illness was the ideal period for detailed investigation. Twenty-seven cases were examined, but in two instances, although the symptoms led to the clinical diagnosis of acute appendicitis, the viscus was found to be normal on examination in the laboratory. Ten control cases of chronic recurring appendicitis were also made use of, more especially for the study of 'fats' and for comparison with the changes in the acute stages of appendicitis.

METHOD OF INVESTIGATION

All the preliminary investigations about to be referred to were made by one of us (P H M) at some period of the abdominal operation.

Blood from one of the arm veins was taken from each patient at the time of operation. Several cubic centimetres of blood were added to the most appropriate media for the purpose, and the remainder was set aside for serological investigations. Urine was withdrawn by catheter. The peritoneal fluid was collected in a sterile tube for bacteriological examination when present in sufficient quantity. The appendix was removed by the usual method, and care was taken that it did not come in contact with the skin or abdominal parietes. It was placed at once in a sterile tube and sent to the laboratories for the detailed investigation about to be referred to.

The viscus was split with sterile scissors from base to apex, and portions of the wall were taken for microscopy. Concretions were removed, and ova were looked for in the depths of the mucosa with a hand lens. The contents of the appendix were spread on sterile unglazed tiles and the dry residue was submitted to bacteriological investigation by the method introduced by one of us (L S D). The mucosa was scraped with a blunt scalpel, the scraping was examined microscopically, and the remainder added to the material on the tiles obtained from the interior of the appendix. By these means, parasites or ova embedded in the appendix wall should not have been overlooked.

Blood Cultures—As already stated, vein puncture was made by one of us (P H M) on each occasion when the patient was under the anæsthetic. The skin was thoroughly cleaned with ether before the vein puncture was

attempted and several cubic centimetres of blood were added to tubes of glucose broth distilled water, and 2 per cent bile salt in distilled water

In 11 out of the 13 positive results obtained, the bacteria were cultivated in the bile medium only, no growth occurred in glucose broth in 23 cases, nor in distilled water in 21 out of the total of 25 cases. In the bile medium *Staphylococcus albus* was obtained on 12 occasions, and *S. aureus* on 3. On clinical evidence all these 25 cases were in the early stages of acute appendicitis of thirty hours' duration or less. A streptococcus cultivated from the blood-stream in one case was non-hæmolytic and of the short-chained type. A massive growth of a similar streptococcus was obtained from the interior of the appendix, which was gangrenous.

The Urine—A detailed examination of the urine was undertaken in 18 out of the 25 cases because symptoms referred to the urinary system occur in acute appendicitis, and we wished to ascertain the relative frequency of *Bacillus coli* infection of the urinary tract in acute appendicitis. It is well known that acute coli infections of the urinary tract may be mistaken for appendicitis, and may occur subsequent to an attack of acute appendicitis.

The urine was withdrawn by catheter in every instance as a preliminary to the operation. *B. coli* was cultivated from the urine in three of the patients with acute peritonitis, and, although leucocytes were present in the urinary deposits in two of these cases, there was no true pus-formation. Mucus, and in one case a trace of blood were also found. In the first of these cases, *B. coli* was not isolated from the acutely inflamed appendix, and the urinary culture of *B. coli* did not agglutinate with any of the anti-colon sera prepared by Dudgeon, Wordley, and Bawtree*. In the second case, *B. coli* was isolated from the pus in the appendix as well as from the urine, but the strains obtained from the two sources did not correspond on cultural evidence, and were magglutinable with the anti-colon sera. In the third case, the *B. coli* obtained from the urine and peritoneal fluid corresponded serologically. In 7 instances the urine was sterile, in the remainder streptococci (4) and *S. albus* (5) were cultivated. Leucocytes were seen in 9 cases blood and mucus in 10, traces of albumin and calcium oxalate in 3 cases.

Agglutination Reactions—The patients' sera were tested with TAB and C antigens, with three hæmolytic, and three non-hæmolytic coli antigens as employed by Dudgeon, Wordley, and Bawtree. There was no evidence of a typhoid or paratyphoid infection in any of these cases but two of the patients showed the presence of inoculation agglutinins, (1) 1-100, (2) 1-200, and in one case a titer of 12, the typhoid end-point was 1-100, but no clinical or pathological evidence of typhoid fever could be obtained. No reaction was obtained with two of the hæmolytic coli antigens (1-50), but in two cases a reaction of 1-100 was obtained with the third hæmolytic coli antigen. Hæmolytic colon bacilli, however, were not cultivated from the interior of the appendix, peritoneal fluid, or urine in any case of this series.

Two cases reacted at 1-100 and one at 1-200 with one of the non-hæmolytic coli antigens, but no further reactions occurred with any of the three

* The anti colon sera referred to throughout this paper are those prepared by these workers

non-hæmolytic coli antigens employed. Colon bacilli, serologically similar, with the bacilli agglutinated, were not isolated from these three cases. We may again recall that the duration of the acute symptoms in these cases was limited to a period of thirty hours, so that the agglutinin content of the sera in the four cases referred to must have been dependent upon a chronic coli infection, or be regarded as within the limits of the normal. Dudgeon, Wordley, and Bawtree, from their observations with normal human sera, and the sera from proved coli cases, considered that a reaction of 1-50 with their antigens at 52° C for five hours was abnormal. In these cases we have taken 1-100 as the lowest limit for the reaction, although the antigens employed and the technique adopted have been the same. If we regard the reactions in these cases as positive evidence of a colon infection, then we must look for evidence of a chronic infection. There was positive evidence of chronic inflammation with fibrosis of the appendix in six cases, but colon agglutinins were not present in the sera of these patients.

THE APPENDIX

Contents—The interior was fully examined in each instance. In one case in which the appendix was found to be normal, the interior was filled with inspissated faecal material which consisted of phosphates and vegetable matter, while the acute symptoms were due to a hæmorrhagic luteal cyst in the right ovary.

In 27 cases, faecal material was present in 2 (the normal cases referred to), creamy pus filled the interior in 3, in 18 cases the contents consisted of blood-stained pus, while in 4 instances it was blood-stained debris. In 6 out of the 25 acute cases concretions were present in addition to the pus or blood. Film preparations of the pus or blood-stained debris showed large numbers of bacteria, sometimes in solid plugs, while in one instance spirochaetes were present in enormous numbers, in the lumen and mucosa of the appendix in a female patient, age 16, who had not been abroad. In 3 cases the terminal one-third or two-thirds showed an inflammatory reaction, while the base was unaffected to the naked eye.

The *concretions*, which were generally grey or greyish-white in colour, consisted of soaps and fats either with or without vegetable matter, but the soaps and fats formed the major portion of the concretion in each instance. No ova or entozoa were found in the interior of the appendix or in the concretions in any one of the 25 acute cases, although a very careful search was made which included scraping of the mucosa. Bacteria were present in the concretions in large masses, but no foreign body was found.

The late Owen T. Williams drew attention to the white, soft, soap-like concretions in the appendix in appendicitis. His analysis showed that these concretions were similar to intestinal sand, and consisted largely of soluble fats and insoluble soaps, with a high calcium content of 33 per cent. He referred to Schmidt, who has stated that the intestinal mucosa excretes inorganic salts of iron, calcium and phosphoric acid, and fatty substances, and to the work of Sir William MacCewen, who demonstrated a secretion in the appendix during life. Williams found that concretions in the appendix

contain insoluble calcium soaps of saturated fatty acids which are formed by the secretion of the appendix, and are not faecal concretions

Williams suggested further that the fat compounds secreted or excreted by the tubular glands of the intestine may under abnormal conditions, block the lumen of the glands, and so render them liable to be more easily infected by micro-organisms than would occur when functioning normally

BACTERIOLOGICAL FINDINGS

The Peritoneal Fluid—Cultures were made of the peritoneal fluid around the inflamed appendix in 12 instances. It was sterile in 4, *S. albus* was present on 3 occasions, once alone and twice with either streptococci or colon bacilli while in 5 instances the positive findings in the peritoneal fluid were similar to those obtained from the interior of the appendix, and showed non-hæmolytic *B. coli* and streptococci

Anaerobic—The pus, blood and debris obtained from the tiles after drying was added to Robertson's heart medium, and sub-cultures were made from this at the end of twenty-four to seventy-two hours. In five cases *B. Welchii* was isolated from the interior of the appendix as shown in Table I

Table I—BACTERIOLOGY OF INTERIOR OF APPENDIX

NO	NO OF CASE	CONDITION OF APPENDIX	AEROBIC	ANAEROBIC	RESULTS
1	11	Normal	Enterococcus Slow lictose fermenter (N H)	<i>B. Welchii</i>	Recovery
2	18	Terminal end necrotic	Streptococcus <i>B. coli</i> (N H)	do	do
3	22	Suppurative appendicitis	<i>B. coli</i> (N H)	do	do
4	23	do	Streptococcus (N H) Enterococcus (N H) <i>S. albus</i>	do	do
5	26	do	<i>B. coli</i> (N H)	do	do

B. Welchii was not obtained from the peritoneal fluid. In one of these five cases the appendix was normal, but in the other four suppurative inflammation had occurred, and although aerobic organisms were present, such as colon bacilli or streptococci, gangrene occurred in one case only. Each patient with this infection made an uninterrupted recovery. These findings are similar to those reported in the work of Dudgeon and Sargent on the bacteriology of peritonitis. In 1898, however, Veillon and Zuber drew attention to the importance of anaerobes in appendicitis. They considered that gangrene and the severe toxæmia were due to these organisms. Tavel and Lanz arrived at similar conclusions. In four acute cases and one normal appendix an

important anaerobe was isolated from the appendix out of 27 cases, but the clinical condition of these patients was not different from the rest, and the surgical treatment and the progress of the case were in no way affected.

Aerobic—The dried pus, blood, and debris were scraped off the tiles in each case and spread on human blood-agar plates and also on plates of agar and litmus lactose agar. By this means it was a simple matter to select the isolated colonies on the various media. The aerobic organisms obtained from the pus and debris, or debris only, in the interior of the appendix in the 25 cases of acute appendicitis (thirty hours) are as follows: *B. coli* 6, *B. coli* and streptococci, 14, streptococci and *S. albus*, 3, *B. coli*, streptococci, and *S. albus*, 2.

We will now discuss these results in detail.

Bacillus Coli—In every case, without exception, the colon bacilli were of the non-hæmolytic variety, which is of considerable interest in the light of the work done by Dudgeon, Wordley, and Bawtree, who showed that hæmolytic colon bacilli occur in the faeces under normal conditions in about 13 per cent, but in cases of diarrhoea and colitis they were much more frequently obtained (35·4 per cent). Herold isolated hæmolytic colon bacilli from the faeces in 40 per cent of his cases of renal infection due to these organisms, while the above-mentioned authors correlated the urinary and faecal findings in hæmolytic coli infections. In these cases of acute appendicitis examined within thirty hours of onset, hæmolytic colon bacilli were not obtained in any instance, although every attempt was made with liquid and solid media. In 1922, one of us (L. S. D.) isolated a pure growth of hæmolytic colon bacilli from the blood and pus obtained from the interior of the appendix in acute appendicitis, but the appendix was full of thread-worms. This colon bacillus was grouped with a hæmolytic colon anti-serum (Dow).

It has already been stated that *B. coli* (N. H.) were isolated from the urine in three of these cases of acute appendicitis, and the organisms from both the urine and peritoneal fluid agreed serologically in one instance. *B. coli* of the non-hæmolytic type were isolated from the interior of the appendix in 22 out of the 25 acute cases. Several strains were taken from each case and tested culturally, but no information was obtained by this procedure, which agrees with the findings obtained with non-hæmolytic colon strains in urinary infections. Each strain was cultivated in veal broth and agar, and antigens were prepared which were tested with the colon anti-sera. In 11 instances non-hæmolytic colon bacilli were isolated from individual cases which agglutinated with the non-hæmolytic colon anti-sera prepared from urinary strains, and none with the hæmolytic anti-sera.

Of course it is possible that if an unlimited number of colonies from every case were tested serologically, a higher percentage of positive findings might be obtained.

Streptococci—Streptococci were isolated from the interior of the appendix in 19 cases out of the total of 27, in one case in the blood culture, and in another from the peritoneal fluid as well as from the interior of the appendix. A hæmolytic streptococcus was obtained in one instance only. This was a short-chained streptodiplococcus isolated in conjunction with a non-hæmolytic long-chained streptococcus, but the degree of hæmolysis was very slight.

The cultural reactions of the streptococci, long and short chains and diplococci in lactose, inulin mannite salicin, and milk and the results of the hæmolytic tests, are recorded here. No detailed description is appended, because distinctive records were not obtained by these methods.

Table II—To SHOW THE CULTURAL REACTIONS OF THE STREPTOCOCCI ISOLATED IN THESE CASES

		HÆMOLYSIS		LACTOSE	INULIN		MANNITOL		SALICIN		MILK	
		+	-	+	+	-	+	-	+	-	+	clot
Long chains	6	0	6	6	1	2	1	5	5	1	2	2
Short chains	5	0	5	5	2	2	2	2	5	—	1	4
Diplococci	13	1	12	13	5	5	9	3	10	1	5	7

+ = Acid - = Alkaline or unaffected

In some cases a long-chained streptococcus and a diplococcus or other combination among the members of this group were found. Hæmolytic streptococci, of the short-chained type, were isolated in only one case, although the hæmolytic tests were done with solid and liquid media. No fatal result ensued and there was no instance of diffuse peritonitis with septicæmia, or cellulitis. The only case from which a streptococcus was isolated by blood culture made an uneventful recovery, but this streptococcus was the short-chained type, and non-hæmolytic. Similar streptococci were isolated from the urine in two cases, and from the interior of the appendix.

Mutch considers that delay of the intestinal movements is one of the chief factors which favour streptococcal growth in the colon, especially when associated with the presence of carbohydrates in the food, while others consider that diarrhoea favours an excessive streptococcal growth. Controversial arguments on this subject are largely due to ignorance of the fact that the streptococcal content of normal human fæces can be shown to be as high as is met with in conditions of ill health, provided the correct technique is employed. This question has been referred to by Dudgeon before the Section of Tropical Medicine of the Royal Society of Medicine.

There is a type of organism occurring characteristically in the fæces which has the classical fermentation properties of the central type of *Streptococcus faecalis* group of Andrewes and Horder, and which withstands heat. Dible considers that this organism is the enterococcus. Heat-resistance is a characteristic property of the enterococcus, as most strains can withstand thirty minutes at 60° C. although fifteen minutes at 60° is the most satisfactory period. Most of our streptococcal cultures were heat-resistant.

MICROSCOPY

Portions of the recently-removed appendix were examined by the ordinary methods and for fibrin bacteria fat and in acid bichromate at 45° C. for fat. Giemsa's stain was also employed and the tissues were examined by Levaditi's method for spirochaetes.

Twenty-seven specimens which had been subjected to full bacteriological and other investigations were examined, as referred to above, and also ten quiescent appendices. Whenever possible portions from the proximal and distal ends, or from the most advanced lesion and the least affected portion, were compared.

ACUTE CASES

The most extreme inflammatory changes were observed either as a localized or diffuse process in the wall of the appendix, while, as might be expected, all stages of inflammation were demonstrated. In 4 cases acute changes at one end of the appendix were compared with the normal appearances at the opposite end. In these acute lesions the mucosa was largely necrosed or a false membrane consisting mainly of polymorphs and fibrin formed the lining wall in the inflamed area beyond the stricture. We failed to observe any marked excess of eosinophils in these acute cases. Eastwood considered that an eosinophilia occurs in the mucosa in appendicitis twenty-four hours after the onset of the attack, and reaches a maximum in the second week, but this localized eosinophilia is not associated with an eosinophilia in the blood.

In the most extreme cases wide areas of necrosis occurred, with acute inflammation of the vessel walls, hæmorrhages, and thrombosis. The thrombi consisted chiefly of polymorphs or of blood debris. Similar changes occurred in the muscular coat: the muscle cells were swollen, vacuolated, and distorted and showed fatty degeneration. There were scattered hæmorrhages present, and tracts of œdema free from cellular exudate.

Table III—SHOWING EVIDENCE OF CHRONIC INFLAMMATION
IN ACUTE CASES

NO OF CASES	CLINICAL HISTORY	EVIDENCES OF CHRONIC INFLAMMATION
2	No previous attack	Chronic inflammation with fibrosis
9	ditto	Chronic inflammation with fibrosis which extends all through the muscular coat up to the mucosa
14	ditto	Fibrosis of muscular coat especially
22	One previous attack	Chronic inflammation all through the appendix
25	Several previous attacks	Marked fibrosis of muscular coat, vessels very fibrosed

The mucosa may show relatively few changes, or small areas of ulceration may be met with communicating with much more extensive inflammatory processes in the muscular coat up to and including the peritoneal covering and peri-appendicular fat. Foci of necrosis occurred in this fatty tissue. The inflammatory reaction may be intense in the submucous and muscular coats, but very slight in the mucosa. Degeneration of the ganglion cells occurred. Spinochætes were abundant in the mucosa and in the lumen of

the appendix in one case, but, as already stated, this patient had not been abroad. It is important to realize that in 5 out of the total of 25 cases of acute appendicitis, positive evidence of chronic inflammation and fibrosis was obtained in addition to the acute changes, as referred to in *Table III*.

One case of oxyuris infection occurred among these acute cases. Remhardt found about 10 per cent of 620 appendices removed up to 1919 contained oxyuris, and during 1919 17.6 per cent out of 170. He considers that localities and seasons may raise the oxyuris index.



FIG. 356.—Zeiss A objective B, ocular. Case 2 (*Quiescent*) showing 'fats' at the base of the columnar epithelial cells of the mucosa and glands with clumping of fats in the central area of the lymph nodes in the appendix wall.

Eastwood found that 19.2 per cent out of 73 cases of appendicitis, and 28 per cent out of 50 normal appendices, had an oxyuris infection.

Fats*—Fat droplets, large masses of fat, and needle-shaped crystals of soaps were present in the interior of the appendix. Fats were present in the cells of the inflammatory exudates and muscle fibres which were not disorganized contained large and small fat droplets. The lymph follicles in

* This term is used to include all substances reacting with Scharlach R.

the wall of the appendices showed small and large coarse fat droplets, especially in the endothelial cells, and these droplets may be of such large size, or so numerous, as to obstruct the outline of the cells. The fats were especially abundant in the endothelial centres. A lymph gland from the mesentery showed the fats in abundance in the centre of the lymph nodes, as occurs in these nodes in the appendix wall. Fats were abundant in the mucous coat, and in the deep epithelium of the tubules, and especially in and around the ganglion cells.

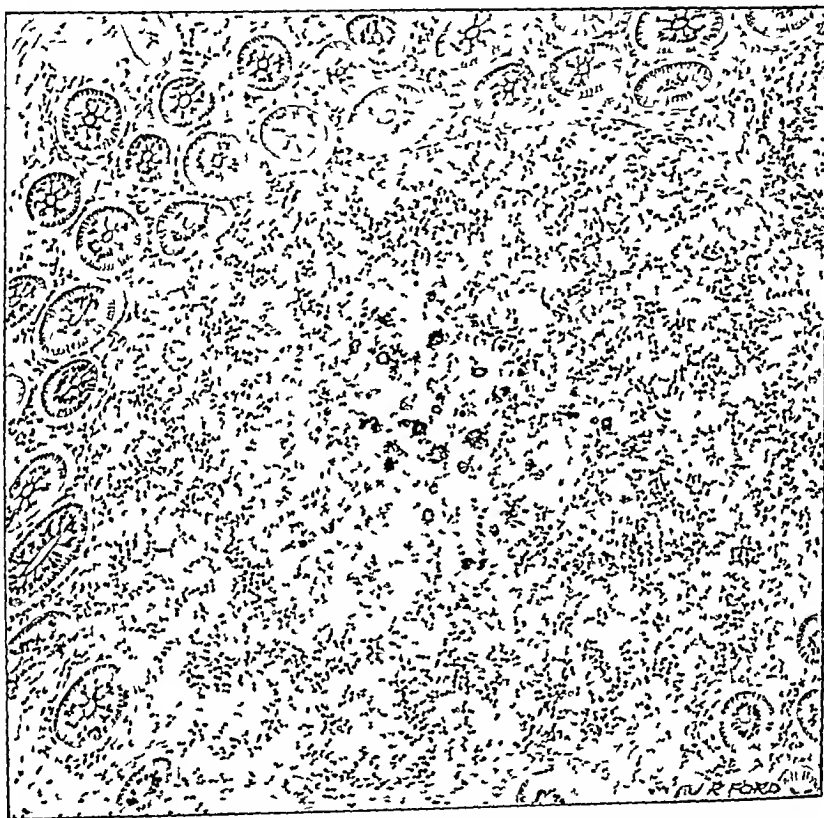


FIG. 357.—Zeiss A objective B_r ocular Case 8 (Quiescent) Showing fats in the epithelium and in the lymph nodes as in Fig. 356

QUIESCENT CASES

Ten quiescent appendices were removed, and examined especially for the presence of fats. The contents were examined and sections prepared as in the acute cases. No bacteriological examination was made. It may be as well at the outset to refer to the gross changes found in the appendix in these ten cases of quiescent appendicitis. In eight out of the ten cases no abnormality was observed in the mucosa, in one case the mucosa was apparently replaced by fibrous tissue, and in the last case the lumen was packed and the mucosa covered with thread-worms. One case of acute appendicitis occurred

in the present series in which thread-worms were demonstrated, but from long experience we have no belief that these worms are a frequent cause of appendicitis in this country. In every case the lumen was fully patent, apart from the thread-worm case, but there was obvious fibrosis of the outer coats.

The microscopical examination confirmed the gross findings, as the mucosa was normal in 8 out of the 10 cases. In one case the mucosa was largely replaced by fibro-fatty tissue, and in the other case masses of ova of the oxyuris were present. No local eosinophilia occurred in this case,

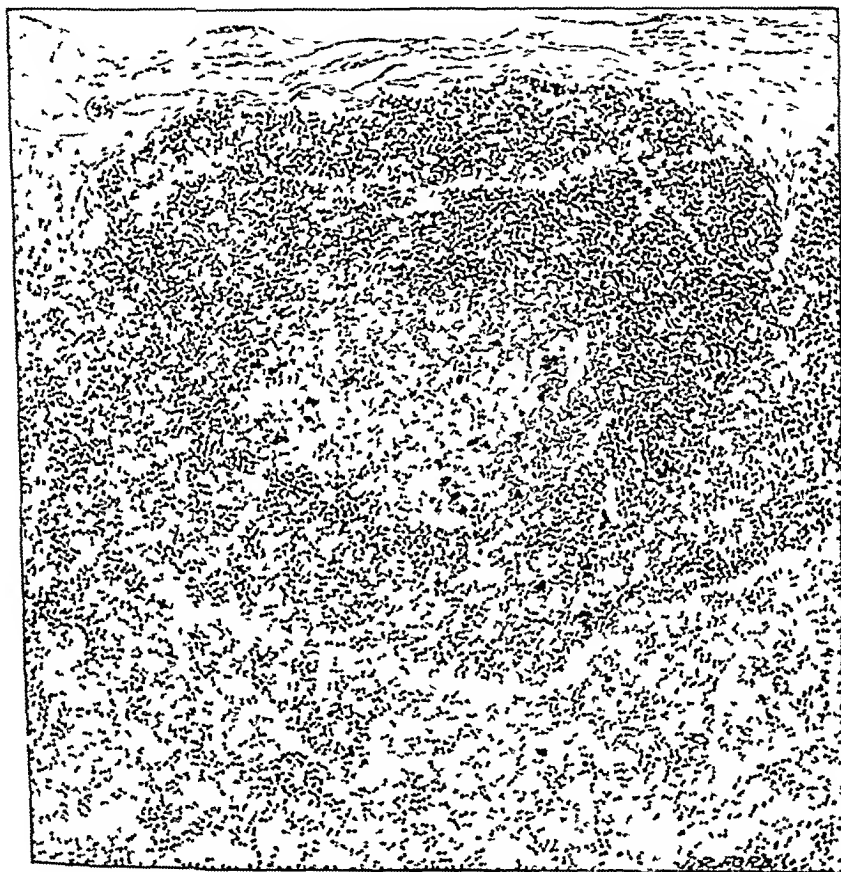


FIG. 358.—Zeiss A objective B, ocular. Case 8 (*Quiescent*). Lymph node from the meso appendix of the same case, showing the same clumping of fats in the central area. A similar condition was to be noted in a lymph node removed from the ileocecal angle and presumably draining the appendix. All these lymph nodes were much enlarged in this case.

which confirms Eastwood's findings. In 9 cases out of the 10 examined the amount of lymphoid tissue was within the limits of the normal.

In one instance endothelial activity in the centre of the lymph nodules was considerable with phagocytosis of the lymphoid cells. The fibrosis was chiefly at the expense of the muscular coat, so that in some cases such muscle as remained was embedded in dense fibrous tissue.

In addition the vessel walls were thickened and the lymphatics in the

outer coat dilated In the fibrous tissue which extended from the submucous to the peritoneal coat, areas of chronic inflammation occurred, and in one instance a deposit of brown pigment, which was not iron-free

The interior showed plugs of bacteria mixed with the faecal material, and in one instance, a female, age 12, who had not been abroad, spirochaetes were abundant

The Fats—It is, however, especially in relation to the presence of the fats that we are now concerned, but some idea of the condition of these



FIG 359—Zeiss A objective B₆ ocular Case 10 (*Quiescent*) Showing a mass of 'fats' in the lumen of the appendix and in the epithelial cells of the mucous membrane and glands Clumping of 'fats' in the centre of the lymph nodes is again present

quiescent appendices was essential before the fat details were referred to Considerable advantage has been gained by employing the bichromate method of Bell for these fresh tissues (*Figs 356-359*)

The fats were found in abundance in the lumen of the appendix with the faecal material, in the cells of the lining epithelium of the mucosa, especially in the deeper portion of the epithelial lining, and in some instances the fats were present here in very considerable amount

It is, however the presence of the fats in the lymphoid tissues of the appendix which is such a striking picture, and especially in the endothelial centres. The fats are present in single droplets, in large clumps, free, and packed in the endothelial cells. We were fortunate to obtain the small lymph gland attached to the appendix in three instances, and here the fats were also found to be abundant, more especially in the endothelial centres in clumps, and in individual droplets, free, and phagocytosed by the endothelial cells. These fats were present in the tissue as round droplets, but the angular or solid forms were also met with.

The fats were present in abundance in the ganglion cells, as in the acute cases, and in close proximity to these cells. The muscle fibres in the appendix wall showed fat droplets, but not to the same degree as in the swollen muscle-cells in the appendix wall in acute appendicitis.

The presence of these fats in the free mucous lining of the interior of the appendix, in the deep epithelial cells, and especially in the endothelial centres of the lymphoid nodules and of the lymph glands draining these areas, suggests to us the probability that fats are absorbed from the lumen of the appendix.

As already stated, Owen Williams brought forward strong arguments in favour of the opposite view—that these fats were excreted by the mucosa of the appendix, and that appendicular concretions were formed in this way. The fact that we have been able to demonstrate fats both free, and phagocytosed, in the lymphoid nodules of the appendix and the corresponding lymph glands, is in support of the view which we offer.

Unless otherwise stated, the appendix showed no signs of previous inflammation, nor adhesions to adjacent structures. The sex incidence in this series is approximately equal, which tallies with a long experience of several years at St Thomas's Hospital. In all cases recovery was uneventful.

CHRONIC APPENDICITIS

Of the 10 consecutive cases operated on in this series, 5 were male and 5 female, of ages ranging from 2 years to 30 years. In no case was the operation performed less than two months after the last acute attack, and in all cases there was no outward sign of previous inflammatory change either in the appendix or peritoneal cavity. In one case that of a female, age 19 years, masses of thread-worms could be felt in the cæcum, and were also found in the appendix. This patient had spent much of her life in Southern India. In another case, a female, age 2 years, where laparotomy was undertaken for an intussusception which was of the cæcocolic type, the appendix was very long and apparently the cause of the trouble.

CONCLUSIONS

1. The chief aerobic organisms isolated from the interior of the appendix in the first thirty hours of appendicitis were *B. coli* and streptococci. These organisms with one exception (streptococcus) were non-hæmolytic. Twenty-five acute cases were investigated. The anaerobe, *B. Welchii*, was present in four of these acute cases but the organism failed to reveal its pathogenicity, and from one normal appendix.

Table IV—CLINICAL NOTES ON THE ACUTE CASES OF APPENDICITIS INVESTIGATED IN THESE EXPERIMENTS

NO	SEX	AGE	LENGTH OF ATTACK IN HOURS	PREVIOUS ACUTE ATTACKS	OPERATION FINDINGS RE APPENDIX
1	F	21	12	1	Cutled up in retrocecal pouch and generally inflamed
2	F	19	12	0	Distal end distended and much inflamed
3	F	25	12	0	No kinking of organ Distal end inflamed
4	M	15	15	0	Distal end inflamed and wrapped in omentum
5	M	14	24	0	—appendix pelvic in position Generally inflamed—pelvic in position
6	F	23	15	8*	Fibrotic and generally inflamed—no adhesions
7	F	9	24	0	Generally and very intensely inflamed
8	M	24	30	0	Generally inflamed—enormous quantities of free serous fluid in peritoneum
9	M	20	20	0	Distal half distended and inflamed, wrapped in omentum
10	M	11	8	0	Kinked by old adhesions and inflamed distally
11	F	16	24	0	† Pelvis generally inflamed Large blood cyst of ovary (R), apparently seat of recent hemorrhage
12	F	8	7	0	Generally inflamed—retrocecal
13	M	36	2	0	Generally inflamed—retrocecal
14	F	15	9	0	Generally œdematous, wall thickened
15	F	45	24	0	Generally inflamed—free fluid purulent
16	M	16	24	1‡	Generally inflamed—free pus
17	F	26	24-30	? 1	Generally inflamed
18	F	8	10	0	† Appeared normal—enlarged glands in mesentery
19	M	33	19	Several	Generally inflamed, adherent and fibrotic
20	M	33	20	?	Tip red No kink Much serous fluid
21	F	21	20	?	End inflamed beyond kink Much serous fluid
22	F	14	6	1	Much inflamed Free serous fluid
23	F	12	24	1	Kinked and much inflamed distally
24	M	29	24	? 1	Generally inflamed and pelvic Very adherent
25	M	24	24	Several	Generally inflamed, pelvic Free sero pus
26	M	16	20	? 1	Inflamed distal to kink
27	M	25	24	0	Generally inflamed

* The e occurred regularly after menstruation on last one month previous to
† Appendix normal microscopically ‡ Three months ago

2 *B coli* was not obtained by blood culture, and streptococci were found in only one case

3 All cases recovered without complications

4 *B coli* infection of the urinary tract was present in three cases

5 Serological tests were made with the anti-colon sera and with the isolated strains of *B coli*, with positive results in half the cases

6 Intestinal parasites were found in one of the acute cases, and in only one of the ten control cases of quiescent appendicitis (oxyuris)

7 Appendix concretions consisted of fats, soaps, and vegetable matter

8 Fats were demonstrated in the lumen, mucous lining, in the gland cells, in the lymph nodes of the appendix wall, and in the lymph glands draining the appendix in the quiescent cases. These findings suggest fat absorption from the lumen

9 In many of the acute cases the inflammatory process in the submucous and muscular coats was much more intense than the appearance of the mucosa led one to suspect

10 Evidence of chronic appendicitis was demonstrated in the wall of the appendix in some of the acute cases, although no previous history of appendicitis was obtained

11 In the chronic cases, and in the acute cases where evidence of previous inflammation existed in the appendix wall, the fibrosis involved the muscular coat, which was extensively disorganized

12 Spirochaetes were found in two cases, and these patients had not been abroad

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THE PROBLEM OF DRAINAGE IN ACUTE APPENDICITIS.

BY R ST LEGER BROCKMAN, SHEFFIELD

(Being the Hunterian Lecture delivered at the Royal College of Surgeons of England on Jan 21, 1924)

“Why then is not the wound of the daughter of my people closed?”

—Jeremias ix 22 (Douai version)

THE history of progress in the treatment of most diseases reveals a series of stages or periods each of which presented its own peculiar problem to exercise the surgical minds of the time. In the practice of the art of healing, we have to tread a path which is strikingly similar to that taken by what to many of us was the most appealing figure of our fairy tales, the suitor who essayed to win the hand of the king's daughter. No sooner is one riddle answered, or one task completed, than another is immediately propounded in its place. We ever repeat the experience of the climber who, thinking the next ridge is the summit to be attained, finds that another rise still stands between him and his allotted goal.

In the not so far distant past the clinical picture of this disease was that of an acute phlegmon of the abdominal wall. The treatment was clear, and afforded no loophole for argument. The problem lay between appendicitis and typhlitis as the underlying cause. This question solved, there arose the stage of discussion over the respective merits of physician and surgeon in dealing with such cases, and more so over the most propitious moment for active interference. The ever-increasing rule of operating on patients as soon as the diagnosis was made at once increased the number and variety of pathological lesions which came beneath the notice of surgeons. What one may call the age of the localized abscess with its inevitable treatment gradually began to pass.

Thus there appeared the problem of drainage in acute appendicitis which is still with us, and to which I propose to attempt an answer.

A good surgeon has been defined as “one who always knows when to put in and when to take out a drainage tube.” If this be so, then there are few other conditions in general surgery which will so often test the standard of our skill. The dictum of Lawson Tait, “When in doubt, drain”, is still the final word in many discussions on this subject. Admirable as such advice has been and is, we must remember that doubt spells ignorance, and complacently to submit one's actions to the ruling of such a motto is to spend a life of surgical stagnation.

HISTORICAL

The earliest suggestion that removal of a gangrenous appendix in the presence of purulent peritonitis can conscientiously be followed by closure was, I think, made by Mikulicz,¹ of Kiakow, in 1884. Unfortunately he

failed to find the appendix, and the patient succumbed to the peritonitis in five days time. The autopsy revealed a perforated appendix. The following sentence of his report is significant: "Had I sought farther for the origin of the exudate, had I investigated the neighbourhood of the cæcum by sight as well as by touch, the perforation of the appendix could not have escaped me, and I should have excised it entirely and closed the opening into the cæcum by sutures. And I am convinced the peritonitis would then have subsided, and the patient would have been saved." Some months later he treated a perforation of the small intestine on these lines, with perfect success.

Others were not so fortunate, and surgery entered upon an era, lasting in many quarters until the present time, which was, and is, dominated by an obsession that a peritoneal exudate of purulent appearance is of necessity pus demanding drainage. To this point I will return later.

In the early part of this century the custom was to provide free and abundant drainage in cases of appendicular peritonitis. Bioca² in 1906 lectured in London in such strain. In the year 1902 Lockwood³ expressed the opinion, "Probably all will agree that when pus is encountered the wound should be drained", and from the context it is clear that he spoke of intra-peritoneal drainage.

At a surgical conference held in Paris in 1911 the general trend of opinion, expressed at a discussion on this subject, was that all cases of acute appendicitis should be drained save very early and exceptional ones. There was, however, evidence that surgeons in various parts were gradually attempting to cut down the amount of drainage employed. Bauer, of Stockholm, told the congress that he had come little by little to do away with drainage in free appendicular peritonitis. The work of Yates,⁴ showing the futility of hoping to drain the peritoneal cavity, was beginning to bear fruit.

In 1912 Grant Andrew⁵ of Glasgow, reported a series of cases to support his contention that general closure of the abdomen after appendicectomy in acute cases should be the rule and practice of surgeons. The atmosphere of his reception was, one gathers from the tone of the discussion which ensued, hardly what a Spaniard would call 'sympatico'. The main criticism levelled was that he was attempting a routine treatment of a condition in which each instance must be considered on its merits.

During the years of the war such a subject naturally almost disappeared from the leaves of the *Index Medicus*.

The year 1920 saw the question again debated amongst the surgeons of Paris. The discussion took place as the result of a paper by M. Ombredanne⁶ in which he pressed for closure without drainage of all acute cases irrespective of the condition of the anatomical lesions which was found at operation. His sole condition was that the appendix should have been removed. His views roused much hostile criticism but it is most interesting to note the large strides which general opinion had made in ten years.

The words of Hartmann⁷ well bear repetition: "*L'indication du drainage résulte non de la présence du pus dans la cavité abdominale, mais de l'existence des particules non résorbables portions mortifiées de sciouse au contact d'un appendice gangréné fausses membranes abondantes présence*

d'une surface cuentec et saignantée" This expression of opinion, first given in 1912 and reiterated in 1920, may be taken as a fair summary of the general feeling of the meeting held in the last-named year

The trend of papers which have appeared in the surgical literature of all lands during the last few years is all towards the elimination of drainage as far as is safely possible in this condition

THE SCOPE OF THE PRESENT OBSERVATIONS

The present paper is the outcome of investigations into the methods of treatment and the results of cases of acute appendicitis which have passed through the surgical wards of the Royal Infirmary, Sheffield, during the three years 1921-23. Only instances of undoubtedly acute inflammation have been included in this series of over 1000 cases. I have made special notes of the causes of death in so far as this event had any bearing on the question of drainage, but otherwise I have purposely rather neglected the pathology of the post-mortem chamber and the realms of experimental work. I have striven to find an answer to my problem according to the dictates of Moynihan's pathology of the living. I shall therefore attempt to show from the result of these observations that the moments of our doubt can be dispelled by a careful interpretation of the clinical and operative findings in each individual case. I fully realize that some will accuse me of rashness, others of being over-cautious, but I maintain that all treatment, if it be rational, must strictly follow the fundamental laws of surgical pathology. Therefore, adhering rigidly to this principle, I have formulated an answer to the question of drainage, which I believe to be in full accord with the best welfare of the patient and with the peace of mind and reputation of the surgeon.

THE ADVANTAGES AND DISADVANTAGES OF DRAINAGE

The first question which naturally arises in our minds is as to whether anything is to be gained by the elimination of general drainage which has been in vogue so long and, if so, to what degree the patient will benefit. What, in other words, are the relative advantages and disadvantages of drainage in such cases? There are many instances where local conditions of hæmorrhage and necrosis will insist on an outlet being provided. There are, however, a large series of cases where it is solely the presence of a purulent exudate which has from long-continued custom necessitated the use of a drainage tube.

In such cases in the main the sole advantage of the practice is what has been spoken of as the hypnotic influence of the presence of a tube on the surgeon himself. There is an old tradition dating from the early days of cœlotomy which leads us to think that a fatal result in an undrained case might have been avoided had drainage been used. This, I think, is untrue unless closure has taken place in the presence of an actual abscess or of a potential one. If the death is the result of lack of drainage, then there is no doubt about it, since the subsequent happenings point only too clearly to *this being the case*. In his article on the treatment of peritonitis cases, Blake⁶

concludes with the following sentence "Some need drainage, some do not, some seem to do better with irrigation others get well without irrigation or drainage, and some die whether drained or not, washed or unwashed" The kernel of truth contained in these words is that, in the absence of what we call a power of general resistance on the part of the patient, we are helpless. No amount of drainage will give the patient what he lacks in this respect. The use of drainage or otherwise should be determined by the local condition aided by certain general observations in each case. The death from failure to cope with his infection is rapid and distinctive in character. It differs greatly from that due to want of drainage, and the two can easily be distinguished.

Further, it is in a very small percentage of cases that anything escapes from the tube. In some it undoubtedly does, often in copious amounts, and it is these cases which demand drainage and which, I hold, give a definite indication of its necessity.

Thus I believe that the hypnotic effect of the drainage tube stands alone as the main advantage of the general use of such procedure in diffuse appendicular peritonitis.

What now are the advantages of dispensing with the use of drainage? The occurrence of faecal fistulas with the enforced delayed convalescence is infinitely more frequent in cases in which a tube has been used. Secondary hæmorrhage has not occurred in any case of this series, drained or undrained, but in no patient has the tube remained *in situ* longer than seventy-two hours. The residual abscess has not arisen in any undrained case, though the same cannot be said of the other class. Of the cases under review, six have come back to hospital after healing with an attack of acute intestinal obstruction due to bands. In all instances they were cases which had been drained at the primary operation. How can this feature be explained? The origin and formation of peritoneal adhesions is a question of great difficulty and complexity. One point, however, can I think, be maintained with a comparative degree of certainty. The type of adhesion which gives rise to trouble of this kind is the outcome of a chronic rather than of an acute infection. The drainage tube is soon closed off by adhesions from the general cavity. Now Yates⁴ observed in his experimental work, and it can be noted in a careful post-mortem examination that the neighbourhood of the tube tract is the common situation of residual abscesses. So a small residual abscess is formed in which the organisms die off, and a chronic collection of pus results. This becomes inspissated and later organized. The movements of the intestine stretch this newly-formed fibrous tissue until it becomes a band which is the cause of the obstruction.

The clinical picture of the convalescence is infinitely more pleasant for the patient in cases in which drainage has been avoided. And lastly, the length of time which such convalescence lasts is considerably curtailed by the practice of non-drainage as can be seen from the tables.

This is I think sufficient evidence that it is well worth our while to eliminate the use of a foreign body in the form of a drainage tube as far as possible in our practice of surgery in such cases.

THE RESISTANCE OF THE PERITONEUM

"Tell me, I beseech thee, wherein thy greatest strength lieth"

—*Judges vii, 6* (Douai version)

Advance in a systematic and logical manner in the inquiry on this subject calls at the outset for a satisfactory explanation of the reason for the pre-eminent powers of resistance possessed by the peritoneum, the existence of which is an acknowledged fact. The ideas of many on this point are too often nebulous and ill-considered. The use in teaching of such phrases as "the selective action of the peritoneum" and "the peritoneum can look after itself" merely tends to conjure up before the mind of the listener a vision of a membrane in the endothelium of which lies some mysterious faculty in which the rest of the body organism is lacking. He is apt to regard the peritoneum as the possessor of the ten talents of secret protective power. With the obvious fact of the existence of such powers he is perforce satisfied, then abode he is prone to regard as lying beyond his ken, hidden away in some at present unsuspected corner as was the secret strength of Samson until it was laid bare by the wiles of the crafty investigator. Some tissues fall an easy prey to certain organisms which fail to affect other parts, but the peritoneum can deal in a very special manner with all and sundry. There is, as far as I can see, no reason in the world why we should look for some obscure and wonderful special immunity in the peritoneal endothelium, since it is born, bred and has its being in the same surroundings as the other tissues of our structure. Furthermore, the simpler an acceptable explanation of vital processes is shown to be, the more likely is the truth to abide therein. Deborah solved the secret of her quest by applying her knowledge of men in general to the particular case of Samson. We can, I think, be equally successful if we will but apply our general experience of the facts and features of inflammation to the individual instance of the peritoneum.

Compare for a moment the effects of infection with the staphylococcus group of organisms in different parts of the body. It is the most universally present organism in cases of peritonitis. In the skin and subcutaneous tissues it usually causes the acute abscess of limited dimensions, the eye-ball it rapidly disintegrates, in joints if not rapidly relieved, the articular structures fall before the onslaught, in bone, however early we locate it, widespread necrosis and sequestrum formation invariably follow. These several sequences are marvellously constant, allowing for even wide differences in the virulence of the infection and the resistance of the individual. How then are they to be explained? The great tissue destroyer is a physical one namely tension, and it is the absence of a rapidly acute tension with its concomitant destruction which explains the extraordinary resistive powers of the peritoneum to infection. How then is the freedom from such pressure provided for in the case of this membrane?

We can regard the peritoneal cavity as a vast tissue space which can accommodate copious pouring out of tissue fluids and exudate without such effusions causing pressure destruction of the cells lining that space. The ease with which fluid can pass through this membrane into the cavity is clearly seen if the peritoneum of a cat is inspected during the intravenous infusion of saline.

Further, in addition to the vessels of the peritoneum which normally carry blood—the service vessels—there is, according to Hertzler⁹ a further set which only dilate and carry blood under the stress of inflammation. Such vessels are described by Klein and Smith,¹⁰ but, according to their account, they often end blindly, and therefore these observers regarded them as freshly developing channels formed by the reactive processes. Hertzler maintains that by improved technique these end-vessels can be shown even in quiescent peritoneum to terminate in veins. Such a mechanism provides an immediate outlet for relieving pressure on cells as the result of acute inflammatory engorgement. These several methods also allow of a very rapid dilution of the toxins formed by the infecting agents.

The looseness of attachment of the peritoneum in the pelvis explains the greater resistance in this region as compared with that in the upper abdomen, where the membrane is firmly bound down to the substance of the liver and the diaphragm.

Now how exactly does this lack of tension and the resistive powers? The limitation of an acute abscess is brought about by the excess of the constructive over the destructive elements of acute inflammation. This is manifested for us by the endothelial proliferation of blood-vessels, lymphatics, and tissue-cells in the zone of the so-called encapsulating area of the infection. A section of the peritoneum (Fig 360)

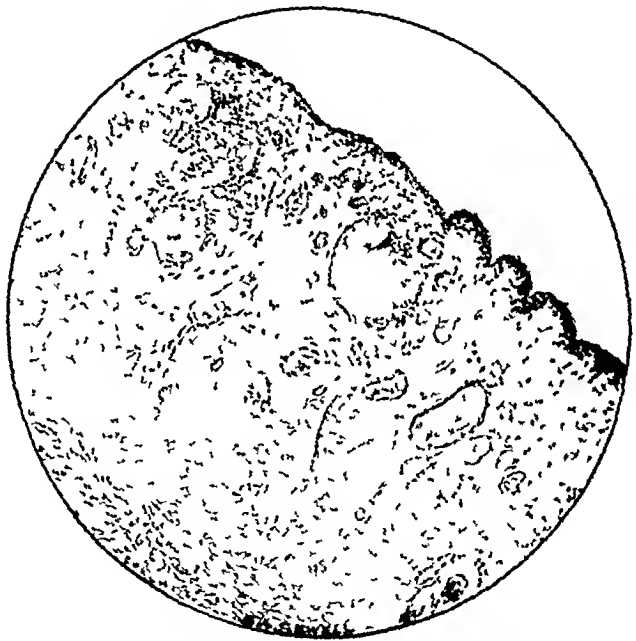


FIG 360.—Peritoneum from a case of gangrenous appendix and purulent peritonitis. The intact but proliferated endothelium can be seen along the entire surface of the membrane.

from a case of acute gangrenous appendix with a diffuse frankly purulent fluid in the pelvis shows that this defensive reaction can, through the lack of tension, be produced in the very forefront of the fray.

Such then is the reason for the existence of such powers of resistance which the peritoneum displays towards infecting agents. Therefore, I maintain the problem of drainage depends for an answer first and last on the state of the peritoneum. The question we have to decide in every case is: Has the damage done by the original focus of infection gone so far that *restitutio ad integrum* is not possible after removal of the primary cause of the inflammation?

If we are to close without drainage we must leave behind an intact

is just becoming turbid. In a sequence of 390 such cases treated by appendicectomy and primary closure, no untoward result has accrued from such practice. The only instance of mortality was due to the onset of pneumonia three days after operation. Such cases, I believe never require drainage in either adults or infants, save in those in which the acute attack occurs in a case where the appendix is buried in a mass of old adhesions consequent upon previous infections. Such removal may entail the leaving of a large area bereft of peritoneum from which the oozing cannot be stopped. In such a case an outlet is obviously required. No case in this class required re-opening for either obstruction or residual abscess. A certain number of wounds broke down, many others oozed varying amounts of turbid serum or pus, but in no case did this give rise to any anxiety as to the ultimate recovery of the patient. It is, I believe, quite unnecessary to suggest that this type of case requires any evidence gained from microscopic examination of the cellular or bacterial content of the peritoneal exudate to enable us to decide whether to employ drainage or not. They can all be closed with safety.

Table C—ACUTE GANGRENOUS APPENDICITIS DIFFUSE PURULENT PERITONITIS

ADULTS									
DRAINED					UNDRAINED				
NO OF CASES	DEATHS	MORTALITY PER CENT	COMPLICATIONS	AVERAGE STAY	NO OF CASES	DEATHS	MORTALITY PER CENT	COMPLICATIONS	AVERAGE STAY
352	30	8.5	Fæcal fistula 20 Obstruction 7 Re opened for abscess 11	25 days	192	14	7.2	Cellulitis 29 Suppurated 160 Perforated 1 Re opened 1 Fistulas 5	18 days
Causes of death					Causes of death				
Within 36 hours 15					Within 36 hours 8				
Paralytic ileus 5					Cellulitis 1				
Obstruction 4					Perforation 1				
Subphrenic abscess 1					Paralytic ileus 3				
Septic exhaustion 5									
INFANTS UNDER 12									
DRAINED					UNDRAINED				
NO OF CASES	DEATHS	MORTALITY PER CENT	COMPLICATIONS	AVERAGE STAY	NO OF CASES	DEATHS	MORTALITY PER CENT	COMPLICATIONS	AVERAGE STAY
54	5	9.2	Fistula 8 Cellulitis 1 Re opened 4	26 days	44	8	18	Fistulas 1 Subphrenic abscess 1 Cellulitis 5 Re-opened or burst open 29	32 days
Causes of death					Causes of death				
Within 36 hours 2					Within 36 hours 1				
Obstruction 1					Cellulitis 2				
Septic exhaustion 2					Acute peritonitis 5				

Class C embraces cases of gangrenous or perforative appendicitis with a diffuse peritonitis often purulent in character. As can be seen from the

figures given, the vast majority of these can be closed without drainage of the peritoneal cavity. Others cannot, and we have now to consider the feature which will enable us to distinguish the latter class of case. In all such cases the peritoneum looks intact to the naked eye. The microscope does not reveal any changes to distinguish them. The section (Fig 361) is an example of the peritoneal surface in all such cases. How is it, then, that we cannot close some, though the majority recover and benefit by primary closure? The cells have obviously undergone some destructive change not apparent

to eye or microscope, which ensures that if we close without drainage the potential becomes an actual abscess.

There are, I believe, certain very definite signs which will enable us to say which of such cases require drainage. In the absence of such evidence, I believe it is perfectly safe to dispense with drainage as far as the peritoneal cavity is concerned. This statement holds for all cases of this class. It matters not how gangrenous the appendix, how copious or foul-smelling the purulent exudate found free in the peritoneal cavity may be. If the indications for drainage which I shall enumerate are absent,

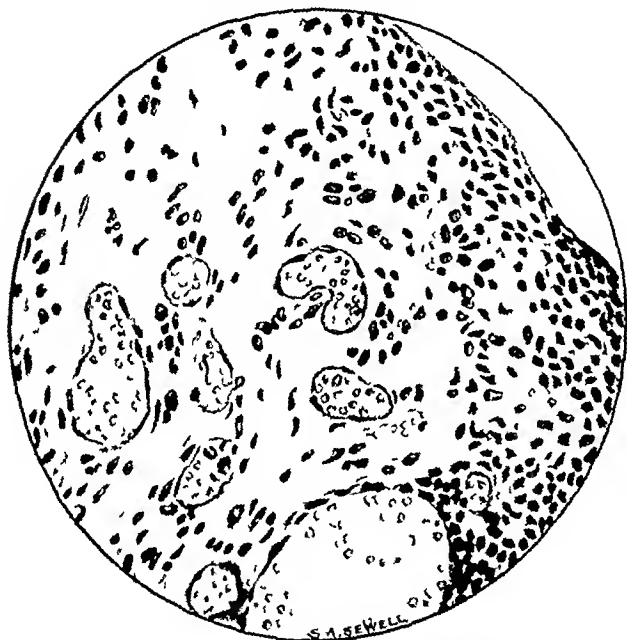


FIG 361.—Peritoneum seen in cases of gangrenous appendix with purulent peritonitis. Neither to naked eye nor to microscope is it apparent whether the case requires drainage or not.

then all such cases can be treated by primary suture of the peritoneum, and, moreover, they should so be dealt with.

I will now consider the evidence upon which our decision can be made.

INDICATIONS AS TO DRAINAGE

Duration of the Disease—The resistance of the peritoneum, depending, I believe, on the absence of tension, is only in the nature of a time allowance which this tissue receives. If we cannot remove the primary focus before this allowance is used up, the defences fail and tissue death results. Cases of this class which have been ill for longer than three days are more likely to need drainage than those dealt with earlier. Though it is important to ascertain the date of onset and allow it to weigh with us, yet we shall find in such cases other evidences which will aid us in our decision.

Age of Patient—If I am asked which is the most valuable single point

of evidence I should say the age of the patient. I am quite prepared to lay it down as dogmatically as possible from this series of cases that children of twelve years and under with a gangrenous appendix and purulent fluid in the pelvis will not stand closure as will adults in a similar condition. I have thought long over the reasons for this undoubted clinical experience. In the first place I am of opinion that in an adult, if the attack which demands urgent operation is without doubt his first, the surgeon is going to have a more anxious case on his hands than if it is the culmination of a series of less acute attacks. Now in children of such tender years the attack for which we operate is almost invariably the first. The youngster has not had the opportunity in a few brief years to develop either a general or a local immunity to such infection. In addition the whole march of events is more rapid, often even fulminating. The time allowance of which I have spoken is used up more rapidly as is evidenced by the comparative frequency with which one meets that bleb-like œdema of the parietal peritoneum in children.

If such a child is closed without drainage, the subsequent history is similar in nearly all cases. They do not tend to develop a small localized abscess either in the pelvis or elsewhere. The damage to the peritoneum has been widespread though at the time of operation it looked glossy and intact, neither have I been able to detect any degenerative change under the microscope which is not present in adults (*Fig 361*). These children ooze pus from the whole surface of the peritoneum of the lower abdomen. If they are re-opened, as they should be or if they are lucky enough to burst open of themselves, a large quantity of pus wells up from all directions and continues to do so for some days. If this does not happen, they usually die of a general peritonitis in four or five days. It is interesting here to study the temperature charts (*Fig 362*) of adults and infants of a series of cases as similar in duration, and in clinical and local condition, as it was possible to collect.

Whilst there is little to choose either way between those of the drained and the undrained in adults when we turn to children under twelve years of age we see a very different picture. The struggle for existence is much more marked and more prolonged in the case of the undrained infant. I am certain that in children of the first decade a purulent fluid within the abdomen demands drainage. They are almost invariably cases of what I have spoken of as the potential abscess. I fully realize the futility of arguing always from statistics, but the difference in the mortality-rate of the two methods of treatment in the case of infants as compared with that of adults is more than significant (*Table C*). The method of drainage I will come to later when I consider that point in detail.

Degree of Toxæmia—This also I feel is one of the most valuable pieces of evidence we possess. It can be judged to a very large extent from the general appearance and facial expression of the patient. The peritoneum in the matter of absorption behaves as does the skin or other surfaces. The existence of stomata as so often described is a myth. Such structures do not exist. They have been shown beyond all doubt to be the products of microscopic preparations—pure artefacts. The power of absorption of toxic substances through an epithelial surface is increased by damage to the cells

of that surface. Little or no absorption of such bodies takes place through an uninjured peritoneum. The degree of toxæmia, then, is a very real guide to the extent of the damage which the infecting agent and its toxins have wrought on the peritoneal endothelium. This damage, as evidenced by an advanced state of toxæmia, is not visible to the naked eye, but is there nevertheless, since such cases, if closed, give rise to the most serious trouble. It is this factor which partly explains the danger of closing the infant to which I have just referred. Marked toxæmia with a rapid onset of the facies Hippocratica is especially a feature of children. As with the young, so with the adult who exhibits this clinical feature, the potential abscess is present in a very real degree, and drainage should be employed.

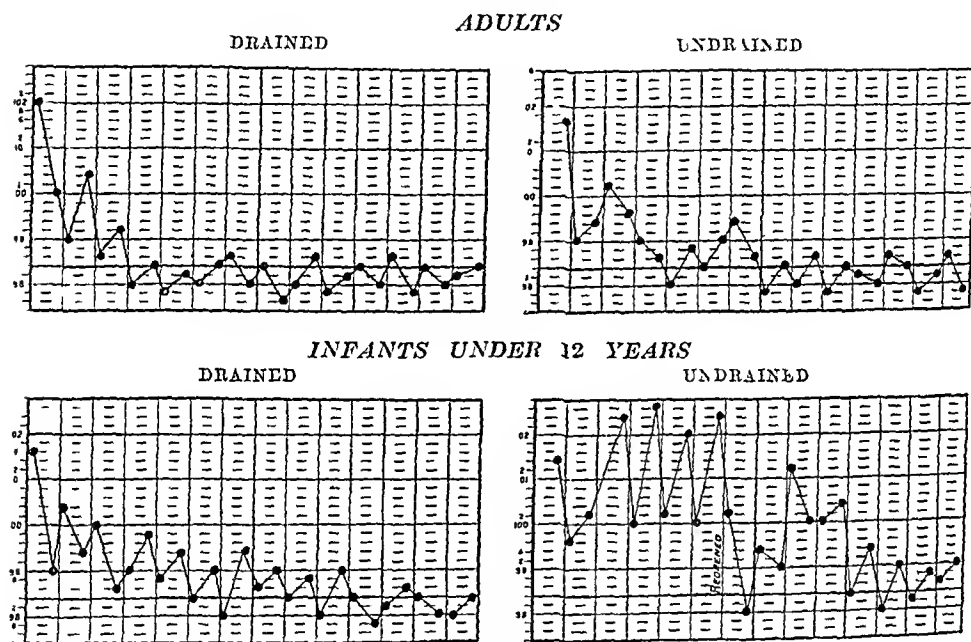


FIG. 362.—Average temperature charts obtained from a series of cases as similar as it was possible to collect.

Presence of Cyanosis—The manifestation of a peculiar cyanosis without dyspnoea, a condition for which I cannot suggest any really feasible explanation, is another sign of advanced toxæmia. It usually foretells a rapidly fatal ending in spite of all our endeavours. Some cases, however, do recover and this feature is a clear danger signal against the practice of closing without drainage in these instances.

The Nature of the Infecting Agent—As a result of investigations into the particular type of organism which was responsible for the condition in many of the series, I am convinced that the isolated fact of knowing the actual infecting agent will give us little or no help in coming to a decision. In the matter of drainage, it matters not if streptococci or *B. coli communis* be the prevailing organism. The important factor is the way in which the patient is able to cope with his infection. The lack of such powers, which

is all-important for us to know is manifested in other ways and it is to these features we have to pay particular attention.

The Condition of the Peritoneal Exudate I have spoken in the earlier part of the paper of a prevailing obsession that an exudate with a purulent appearance is pus demanding drainage. The drainage of a pus containing cavity is demanded not by the fluid it contains which we can evacuate by surgical means but by the condition of the walls of that cavity which we know will ooze further pus after we have dealt with it. It is exactly this principle which binds with equal force in the case of the peritoneal cavity. How far then can the character of the fluid we find be depended on to guide us as to whether more pus will come from the peritoneal membrane or not? Wilkie¹² holds that an immediate examination of the fluid will give us the necessary information which will enable us to come to a decision. He claims that the lack of large mononuclear cells then failing power for absorbing stains and the absence of phagocytosis are evidence that drainage is required. From my own observations on repeating his work in many of the cases here recorded I have come to the conclusion that such features are of the utmost value in prognosis. If those three characteristics are definitely present the case is beyond all our surgical aid. Death will ensue in a short time whether we drain or not. This view is I think also borne out by the cases which Wilkie reports in his paper. Carslaw¹³ started some investigations with the primary object of ascertaining the relation of the exudate to drainage. In his conclusions he points out the prognostic value of such examination but maintains that its value in dealing for or against drainage is greatly modified by the frequent demand for local drainage and the impossibility of effectually draining the general peritoneum. Wilenski¹⁴ of the Mount Sinai Hospital has recently published a paper in which he contends that the question can be settled by the number of organisms per microscopic field in a film of the exudate. He shows that in the type of case embraced by *Class B* few or no bacteria are seen in film in such exudates. This is the experience of all who have so examined these cases. He has in consequence closed all patients of this type as I have, without any untoward results. Then his logic somewhat fails. He now reports that films from cases of gangrenous appendicitis with diffuse peritonitis contain numbers of bacteria. In such cases he simply declares that drainage was frankly indicated. He has taken them as his controls, and has not attempted to close them so that he might really test the correctness of his contention.

It is the fluid in this latter type of case to which I have paid special attention. As a result of comparing the number of organisms seen with the after histories of drained and undrained cases, I am convinced that this factor is of no more value to us than is the knowledge of the actual type of organism responsible. The same applies to the type of cell seen. There is, I believe no value in, or need for, such immediate microscopic examination of the fluid in enabling us to come to a decision. The gross naked-eye characteristics of the exudate are quite sufficient for the surgeon to rely upon.

In the first place, the quantity of fluid present carries great weight. It can be taken as a good rule that the greater the amount found, the safer it is to close without drainage, provided that the exudate, however purulent

it may be is homogeneous in appearance. A gangrenous appendix with a dry peritonitis of the diffuse variety requires drainage, since the toxins have not been diluted and their power of damage to the endothelium is mostly unimpaired. The presence of a blood-stained purulent exudate even though copious calls for drainage. The hæmorrhage is the result of capillary damage and subsequent loss of epithelium. I have stipulated that the fluid should be homogeneous. The abundance of definite flakes of coagulated lymph, which are largely composed of agglutinated leucocytes is another indication for drainage. The production of experimental peritonitis in animals is greatly facilitated by the presence of gross foreign particles. This explains the reason why cases with false membranes continue to form and ooze pus after the removal of the appendix.

An exudate which has been described as having the appearance of beef-tea precludes closure with any degree of safety. The majority of such cases succumb, but in free outlet lies their only hope of recovery. Apart from these conditions the presence of a purulent peritonitis does not of itself demand drainage.

What now is the correct procedure with regard to the removal or otherwise of the exudate in these cases of gangrenous appendicitis? To me, it is material which has done its work and has to be absorbed by the peritoneum. I personally would remove it by some method of siphonage in all cases. I have been still more convinced of the correctness of this procedure by reading the reports of cases in the early days of abdominal section. The oft-repeated improvement for two or three days after simple incision and evacuation of the purulent exudate is remarkable, so much so that I believe that if we remove this fluid at operation we lift a considerable load from the shoulders of the patient in his work of recovery. This clinical observation outweighs in my mind any theoretical evidence as to the presence of antibodies, which is sometimes put forward as an argument for leaving such exudate untouched.

The Condition of Appendix, Cæcum, and Intestines—The degree of gangrene or perforation of the appendix matters little in the question of drainage, provided that this organ is lying free within the peritoneal cavity. If it is bound down by adhesions or is extraperitoneal a raw infected surface of connective tissue is left which demands local drainage. It is useless and pathologically unsound to close this area in by approximating the edges with sutures in view of the infection present. It is simply sewing up a wound which we know is contaminated with virulent micro-organisms. Any signs of extensive thrombosis or threatened gangrene of cæcum or intestine has a bearing in the same direction. The presence of marked œdema of these parts as evidenced by definite thickening of their walls or roughening of their peritoneal surface, gives grave warning that closure may lay up serious trouble for us during ensuing days. There are cases, fortunately rare in which the whole of the intestines and omentum present a peculiar cyanosed appearance as if stained by the products of a hæmolytic process. To close such cases is to court disaster.

The Appearance of the Omentum—One of the chief functions of this 'policeman of the abdomen' in cases of diffuse peritonitis is to pick up and ingest organisms free in the exudate. If marked thrombosis is evident or

if the surface is covered with an abundance of coagulated lymph this faculty is greatly impaired and in consequence delayed abscess formation is prone to take place if drainage is not employed under these conditions

THE RELATION OF OPERATIVE TECHNIQUE TO DRAINAGE

One of the greatest stumbling-blocks to the successful culmination of drainage is the practice of attempting to deliver the appendix outside the abdominal incision before removal. If the appendix is adherent to surrounding structures it should be removed by what is called retrograde appendicectomy. If the start is made at the attachment to the cecum the appendix can be removed under vision with the minimum of damage. The art of gentleness thus practised in this operation will considerably increase the percentage of cases which it is safe to close.

METHODS OF DRAINAGE

The types of drainage which we have at our disposal fall under three headings: (1) *Local drainage*, (2) *Pelvic drainage*, (3) *The safety-valve drain*. In all instances the material used is rubber tubing. What are the conditions under which each should be used?

Local Drainage This is called for where the invagination of the appendix stump is insecure, where a subsequent fecal fistula is feared, for local oozing, and for the drainage of an abscess cavity shut off from the general peritoneum.

Pelvic Drainage The general use of this procedure was the outcome of what is always spoken of as Fowler's position. It is not within the limits of my subject to discuss how far this position does really allow of gravitation of fluid to the pelvis, but apart from such questions there are, I believe, other very strong factors against the use of such a method of drainage. A rubber tube in the peritoneal cavity is shut off by adhesions within a few hours. It merely serves to extraperitonealize a certain area with which it is in contact. It is often used in a case of diffuse peritonitis. Now it can only drain a very limited area of the pelvis at the best. What happens to the rest of the infected area? It obviously takes care of itself and recovers without drainage. It is reasonable to argue that the whole area could have reacted in the same way without the use of a tube at all. The only indication for the use of a drain to the pouch of Douglas is the presence of an abscess cavity in that situation at the time of operation.

Safety-valve Drainage—I have pointed out that cases which are closed when a potential abscess is present ooze pus from a large area of peritoneum. These cases simply require what I have called a safety-valve outlet through which such pus can find its way if formed. This can be provided by passing a tube just through the incision in the parietal peritoneum. Such procedure is all-sufficient, and is devoid of all the disadvantages of a pelvic drainage tube.

The list of features which call for drainage must appear somewhat lengthy, so much so that at first sight it would seem to nullify the aim of my

paper, which is clearly to advocate a more general practice of primary closure of the peritoneal cavity in this disease. In actual practice it will be found that the result of following such procedure as I have formulated is that almost all cases of adults can be closed without drainage, but children should be drained by means of the safety-valve tube.

THE TREATMENT OF THE ABDOMINAL WALL

Though we may close the peritoneum in the vast majority of such cases with a safe conscience, we shall court disaster if we attempt so to deal with the incision in the abdominal wall. Skin edges when brought into close and careful apposition become firmly sealed in quite a short space of time. In consequence a diffuse cellulitis of the layers of the abdominal wall develops beneath. In some cases nothing more serious occurs than a severe disappointment to both patient and surgeon when the wound completely breaks down at the end of a few days, discharging a considerable amount of pus. In others a state of affairs which endangers the patient's life is the result. The cellulitis tracks down the inguinal canal to the scrotum or labium, or more commonly round to the tissues of the loin. In three cases of this series death resulted from a streptococcal cellulitis of the abdominal wall after closure, where the peritoneum had adequately dealt with its portion of the infection. The French explain such suppuration of the wound as due to the catgut, which they hold acts as does the injection of turpentine in the formation of a fixation abscess. The discarding of buried sutures and the fixation of skin and fascial planes by figure-of-8 silkworm-gut sutures has in my experience made no difference in the frequency of such suppuration. The use of rubber dams, carbolyzed vaseline, and other antiseptics has likewise failed. The greatest measure of success in preserving the integrity of the abdominal incision can, I am sure, be ensured by a method of draining each layer of the abdominal wall which was described by Eisendialth¹⁵ (*Figs 363-7*). I have had copies made from the illustrations from his article, and am convinced of the efficacy of this form of treatment. By a series of rubber tubes he provides drainage for each layer of the incision, as can be seen from the sketches. These are left in till the stitches are removed, and both taken out together. In the cases in which I have employed it, I have utilized thin stitch tubing, and by splitting one tube longitudinally have placed half above and half below the external oblique, thus doing away with the twisted strand of salmon gut.

Another important factor in the prevention of breaking down of the wound is to remove any suture the instant that the patient experiences the slightest itching in its neighbourhood. Such a simple procedure, if acted on, will preserve intact scores of wounds which would otherwise completely break down.

At the beginning of the lecture I pointed out that in the study of disease the solution of one problem is merely the prelude to the appearance of a further riddle, which arises directly from the previous successful answer. I do not claim to have given a complete answer to the problem of drainage in

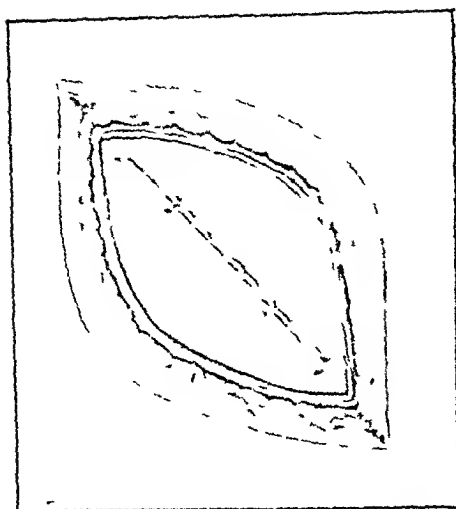


FIG. 363—Parietal peritoneum completely closed by primary suture (Figs. 363-367 are after Eisendrath)

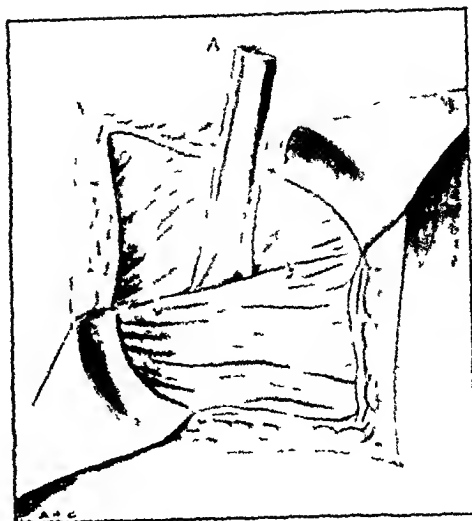


FIG. 364—A Tube down to peritoneum

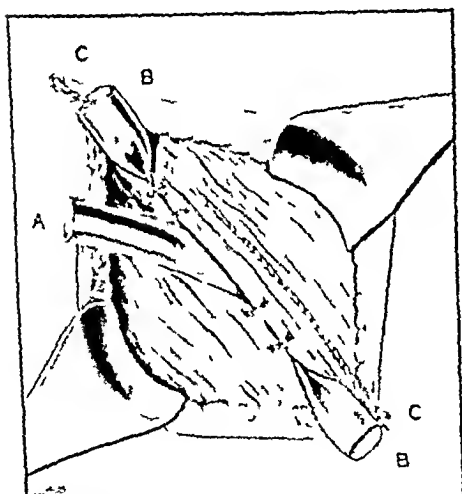


FIG. 365—B Tube lying below external oblique C Strand of silkworm gut above external oblique

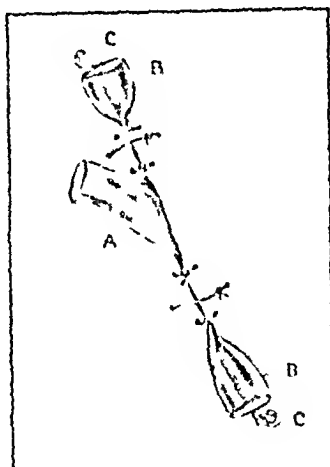


FIG. 366—Skin incision closed showing arrangement of drains

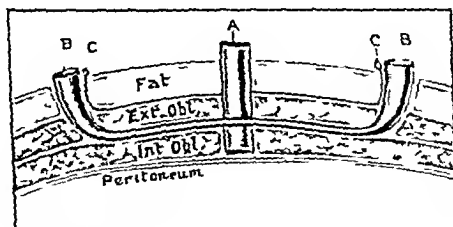


FIG. 367—Diagram showing that each layer of the abdominal wall is provided with an outlet

acute appendicitis, but my investigations have taken me far enough along the road to see that this question of diaphragm can only be definitely settled by a true understanding of what really constitutes the power of resistance to infection. If a patient possesses an abundance of such resistance, it is immaterial whether we drain or not—he will recover without giving the surgeon undue anxiety. If such power is absent trouble is in store for us whether we close or drain. Until further light is shed on this immense field for research, I believe we can safely act upon the lines which I have indicated.

If we so attempt to deal with the problem of diaphragm in acute appendicitis, we shall lose that feeling of suspicious awe on hearing that cases of diffuse purulent peritonitis from this cause are closed without diaphragm and our outlook towards this branch of surgery will best be described by the words of the prophet of old: "Why then is not the wound of the daughter of my people closed?"

To those who still think that a gangrenous appendix with a diffuse purulent exudate is a condition which always demands diaphragm, I would venture to repeat some advice given many years ago by him whose name this lectureship bears. Apt as such advice was then, it still remains so and will be for all time: "Do not think, but try", and in so trying, I can fully assure you that you will not suffer disappointment.

In conclusion, I wish to express my thanks to the surgical staff of the Royal Infirmary, Sheffield, for kindly allowing me to use their cases, but more especially to Professor Connell, whose practice of general closure of abdomens after appendicectomy really first stimulated my interest in this question.

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BLOOD CHANGES ASSOCIATED WITH METASTATIC TUMOURS OF BONE

BY A. PINLY, London

The subject of secondary carcinomatous deposits in bone has been discussed in a number of publications within the past year (Joll¹ Pinoy²) but these papers have dealt mainly with the local manifestations of the condition and with the mechanism by which the deposits are conveyed to the bone marrow. No interest appears to have been aroused in the changes in the composition of the blood which might be expected to result from the lodgement and growth of a tumour mass in the midst of hemopoietic tissue.

The literature of medicine and haematology contains a number of reports of cases of secondary carcinoma of bone and in a few of these the condition of the blood is recorded. In 1878 Ehrlich³ recorded a case of 'pernicious anemia' developing in a patient who was affected by a malignant tumour of bone (probably a sarcoma) and this appears to be the first case of 'metastatic anemia' which is available in the literature. One of the early records which contains a detailed hematological report is that of Harrington and Teacher.⁴ Their case was that of a woman who was suffering from latent carcinoma of the stomach and whose blood showed —

Red corpuscles	1,600,000 per cmm	Colour index	1.09
Hemoglobin	35 per cent	Leucocytes	11,000 per cmm

Myelocytes formed 0.5 per cent of the total leucocytes at the time of this examination but at a later date the colour index had fallen to 0.9 and the percentage of myelocytes had risen to 5. Nucleated red cells were numerous, both large and small forms being seen. The peculiar blood picture was discovered about three weeks before death.

Harrington and Kennedy⁵ also described a case of carcinoma of the stomach with similar changes in the composition of the blood picture but this case differed from that of Harrington and Teacher in that the diagnosis of carcinoma of the stomach was obvious on clinical evidence while in the former case the primary growth gave rise to no very suggestive symptoms. Ward⁶ has recorded a case with similar grave alterations in the blood picture in a woman suffering from recurrent carcinoma of the breast. Unfortunately the diagnosis of secondary carcinoma of bones could not be confirmed as an autopsy was not permitted. The colour index in this case was below unity. Paimentier and Chabrol⁷ have also recorded cases in which the metastases were secondary to carcinoma of the stomach. Eosinophilia was present in their cases. Epstein⁸ has presented a detailed report of the hematological findings in a case in which the primary carcinoma was in the mammary gland. Reichmann's⁹ case was secondary to a carcinoma of the oesophagus and showed a low colour index although all the other typical features were present.

Schleip¹⁰ reported a series of three cases in which the primary foci were in the jaw, the stomach, and the appendix respectively. Kurpjuweit¹¹ has also reported several cases of this type in which the alterations in the blood picture were distinctive. It will be noted that the characteristics of the blood picture as detailed by these authors show some resemblance to those of pernicious anaemia, but there is invariably leucocytosis and there is no lymphocytosis either relative or absolute.

The case reported by Bizzani¹² showed changes more reminiscent of leukæmia than of pernicious anaemia, thus —

Red corpuscles	1,200,000 per c mm	Leucocytes	13,300 per c mm
Hemoglobin	15 (Fleischl)	Nucleated red cells	24,700 per c mm
Colour index	0.62		

A differential count of the leucocytes showed —

Myeloblasts	13 per cent	Eosinophils	1 per cent
Promyelocytes	9 "	Lymphocytes	20 "
Myelocytes	7 "	Hydines	6 "
Metamyelocytes and poly-morphonuclears	41 "		

The error in the total occurs in the original paper

In this case the primary growth was in the stomach and was a carcinoma. So striking is this blood picture that one might be tempted to consider the possibility of the occurrence of leukæmia and carcinoma of the stomach with bone metastases in the same patient, but another case has been recorded in the literature and one will be presented later in this paper in which a somewhat similar change occurred and leukæmia could be excluded with certainty at autopsy.

The few cases which have been thus reviewed will suffice to demonstrate that 'metastatic anaemia' is a well-defined condition. Other authors who have recorded cases and discussed the matter are Cantieri,¹³ Ferrata and Negrenos-Rinaldi,¹⁴ Luzzatto,¹⁵ Rotky,¹⁶ and Hirschfeld.¹⁷

The present writer wishes to record and discuss three cases which present features of interest in this connection.

Case 1 — The patient was a man, age 58, who had been failing in health for about three months, although he could not describe any definite symptoms. The only clinical finding was extreme pallor of the skin and mucosæ.

Examination of the blood showed —

Red corpuscles	1,200,000 per c mm	Colour index	0.6
Hemoglobin	15 per cent	Leucocytes	30,000 per c mm

Enumeration of the different types of leucocytes in stained films showed —

Neutrophil polymorpho-nuclears	47.5 per cent	Myeloblasts	5.0 per cent
Neutrophil metamyelocytes	12.0 "	Lymphocytes	17.5 "
Neutrophil myelocytes	12.5 "	Hydines	4.0 "
			1.5 "

The stained red corpuscles showed poikilocytosis, anisocytosis, and polychromatophilia. While counting 1000 leucocytes 2830 nucleated red cells were seen. The nucleated red cells were all of the normoblastic type, although 980 were large and polychromatophilic (macroblasts).

At the post-mortem examination an ulcerocarcinoma of the stomach was found with metastases in the regional lymphatic glands in both humeri and both femora.

is well as in the vertebral column. Fig. 368 shows the appearance of the right humerus on longitudinal section. On histological examination the tumour was found to be a sarcoma, and the deposits in the marrow were of the same type, although there was less fibrous tissue than in the primary growth. Plugs of tumour cells were seen lying in the blood channels (Fig. 369).

Case 2. The patient was a man, a *c. 50*, who had been failing in health for about six months, at which time he was recovering from an attack of pleurisy. He complained of pain over the humeral region of the vertebral column, and had been losing weight rapidly. A mass of soft tissue was felt attached to the sixth rib on the left side. Examination of the blood showed —

Red corpuscles	5,683,000 per c. mm.
Hæmoglobin	78 per cent.
Colour index	113
Leucocytes	8,000 per c. mm.

A differential count of the stained leucocytes showed

Neutrophil polymorphonuclears	77 per cent.
Lymphoid polymorphonuclears	1
Neutrophil myelocytes	2
Myeloblasts	0.6
Neutrophil metamyelocytes	1
Lymphocytes	7.3
Large lymphocytes	1
Erythres	5

The stained red cells showed poikilocytosis, anisocytosis, and very slight polychromatophilia. While counting 1000 leucocytes 4 nucleated red cells of normoblastic type were seen.

A second examination of the blood was made a few hours before death, but only sufficient blood for the preparation of films could be obtained. The composition of the blood picture was practically identical with that found at the first examination, with the one difference that nucleated red cells were more numerous, 57 being seen while counting 1000 leucocytes. At autopsy the primary growth was found in the lower lobe of the left lung, and metastases were found in the humeri, femora, and vertebral column. Histologically the tumour was a spindle-celled sarcoma, and the deposits in the marrow (Fig. 370) were of the same type.

This case illustrates a type of blood change dependent upon the presence of a secondary deposit of sarcoma in the bone-marrow, and it will be noted that the changes are of the same character as those due to carcinomatous deposits. Cases in which the blood has been investigated in this condition are not numerous in the literature, but the case of Dieballe and Entz,¹⁸ which was described in detail, is of this type. It was a spindle-celled sarcoma of the pleura in a girl, age 15. At autopsy, metastases were found in the humeri and



FIG. 368. Case 1.
Section of humerus showing metastases in the hyperplastic red marrow. No invasion of bone is seen.

in the upper third of the femora. The blood picture in the case presented very unusual features —

Red corpuscles	2,608,000 per c mm	Colour index	0.78
Hæmoglobin	41 per cent	Leucocytes	112,600 per c mm

The differential count of the leucocytes showed —

Neutrophil polymorphonuclears	82.8 per cent	Lymphocytes	3.6 per cent
Eosinophil polymorphnucleus	0.7 „	Neutrophil myelocytes	9.8 „
Basophil leucocytes	0.2 „	Eosinophil myelocytes	0.25 „
Hyalines	2.3 „	Myeloblasts	0.1 „

The error in the total occurs in the original paper

In each c mm of blood 300 nucleated red cells of normoblastic type were found



FIG 369 —Case 1. Section of metastases in marrow. A plug of tumour cells is seen living in a blood channel.



FIG 370 —Case 2. Section of metastases in marrow showing the spindle cell character of the tumour and the diffuse growth in the marrow.

The authors conclude that the presence of a considerable percentage of myelocytes in the blood in cases of malignant tumours is highly suggestive of the presence of metastases in bones.

Case 3 does not require detailed consideration, as it has been carefully reported by Broster¹⁰ from this laboratory. The tumour was a secondary hypernephroma situated in the femur. The blood was not examined until the day after amputation of the leg had been performed, when 0.5 per cent of myelocytes and 1.5 per cent of myeloblasts were found. There was practically no anaemia. Broster publishes a photomicrograph which demonstrates the intravascular situation of the metastases in the marrow.

Two main points which emerge from consideration of these cases are —
(1) The changes in the composition of the blood do not depend upon the site

finely reticular nuclei (megaloblasts) The megaloblast corresponds to the type of nucleated red cell found in the early embryo, while the macroblast appears during later embryonic life and is to be regarded as an immature normoblast In brief, the blood picture in metastatic carcinoma corresponds to a late embryonic type of hæmatopoiesis, while in pernicious anæmia the process may be said to revert to the early embryonic type The differential diagnosis of metastatic carcinoma from pernicious anæmia should present no difficulties if these criteria are borne in mind, but the differentiation from leukaemia may be difficult A valuable differential point is the invariable absence of a marked increase of basophil leucocytes in metastatic anæmia whereas this is almost invariably present in leukaemia and the presence of even a few basophil myelocytes may be regarded as very strong evidence of the leukæmic nature of the case

The histogenesis of the blood changes is still uncertain but the present writer has briefly discussed this matter in a previous publication² Any attempt at the explanation of the histogenesis of this blood picture must be preceded by a brief resume of the histology and anatomy of the marrow the normal adult has marrow in the upper ends of the proximal long bones, in the ribs, and in the vertebrae this is described in detail elsewhere by the present writer²²

Histologically the marrow is built up of a series of thin-walled, wide blood channels in which the blood-flow is extremely slow between the blood channels are the parent cells of the granular series of leucocytes, while in the lumen of the channels the process of erythropoiesis takes place This intravascular erythropoiesis occurs both in the adult and in the embryo, as has been shown by Dantschakoff²³

No lymphatic channels have been demonstrated in the marrow of man or any other animal The periosteum of the affected bones in the present series of cases was carefully searched for evidence of permeation, but no signs could be found this also applies to a previous series of cases which the present writer has published,² and in Bioster's case no signs of periosteal involvement could be found

The inevitable conclusion is that metastatic deposits in the bone-marrow are blood-borne and are therefore intravascular in position, as the author has demonstrated² and these conclusions are in conformity with the findings of Declmann,²⁴ Bioster,¹⁹ Joll¹ and many others

If this intravascular position of the metastases be accepted it will be obvious that the first irritative effect of such deposits will be exerted upon the intravascular erythroblasts but at a later stage, when the emboli have grown into the surrounding leucopoietic tissue there will also be severe irritation of the leucopoietic mechanism

The fact that secondary sarcomata of bone may give rise to a blood picture identical with that caused by metastatic carcinoma is difficult to explain unless the hæmatogenous origin of carcinomatous bone metastases be accepted The hæmatogenous spread of sarcoma is universally accepted, and it is unnecessary to postulate any other mechanism for the explanation of the blood picture in secondary carcinoma

SUMMARY

- 1 A specific type of blood picture is described which depends upon the infiltration of the marrow by secondary deposits of tumours or granulomata
- 2 The characters of the blood picture may be roughly divided into two main classes namely, those of the pseudo-pernicious and those of the pseudo-leukæmic type
- 3 The hæmatogenous origin of marrow metastases is re-assumed

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CYSTIC PNEUMATOSIS OF THE INTESTINAL TRACT

BY CYRIL A R NITCH, LONDON

(Presidential Address delivered before the Section of Surgery of the Royal Society of Medicine in November, 1923)

THE full and Continental name for this remarkable pathological condition is *pneumatosis cystoides intestini hominis*. The two cases on which this paper is based have already been recorded by Professor Shattock and myself in the Proceedings of the Section of Pathology of the Royal Society of Medicine for 1919, but as the annual output of medical literature is so vast that the

practical surgeon cannot keep pace with it, I have ventured to refer to them again

Case 1—A schoolmaster, age 48, who had suffered for fifteen years from troublesome flatulence and recurring attacks of epigastric pain about one and a half hours after food. The attacks lasted for a month or more, and the pain, which at times was very severe, was always relieved by vomiting. In 1912 the pain became almost continuous, and was accompanied by abdominal distention and increase of flatulence. On the advice of his doctor he consulted Dr A E Russell, who diagnosed pyloric stenosis secondary to ulceration, and advised an operation. As the patient refused surgical treatment, his doctor taught him to wash out his stomach with a rubber tube, and thus he carried out daily for six years. The lavage conferred relief, but, as might be expected, he became so weak and emaciated that in June, 1918, he only weighed 7½ stone. He was then persuaded to submit to an operation and entered St Thomas's Hospital on June 29, 1918. He was very weak



FIG 371—Case 1. Portion of the small intestine as it appeared when exposed showing numerous gas blebs projecting beneath the peritoneum. Redrawn from a sketch made whilst the gut was exposed during life. (Natural size)

and thin. His stomach was so greatly dilated that its lower border was level with the crest of the ilium. There was moderate gastric peristalsis. I operated upon him on July 3 and found an extreme degree of stenosis of the pylorus, for which a posterior no-loop gastrojejunostomy was performed. On drawing up the great omentum to prepare the field for the anastomosis, a coil of small intestine, studded with greyish-white glistening elevations presented in the wound (Fig 371). On closer examination these proved to be multilocular subperitoneal cysts, varying in size from a pin's head to a pea, and on puncturing one of them I was astonished to find

that the contents were gaseous and not fluid. The cysts were dotted more or less evenly over the whole circumference of the bowel and there were also a few about twice the size of a pin's head in the transverse mesocolon and at the base of some of the appendices epiploicae. With the exception of the last 12 inches of the jejunum and the last 12 inches of the ileum the whole length of the small intestine was affected. The freedom of the first part of the jejunum was fortunate, as otherwise in mastomosis would have been attended with grave danger of leakage, owing to the multiplicity of the cysts. The mesentery of the small intestine and the walls of the stomach, duodenum and colon were normal. The patient made an uninterrupted recovery. Two and a half months later, though he still had occasional flatulence, it caused him neither



FIG 372—Case 1. A. A narrow piece of the small intestine excised during life viewed from the inner aspect. The mucous membrane is raised in hemispherical eminences by the presence of gas in the submucosa. At each end a portion of the divided muscular coat is shown. (Natural size.)

B. A section made through a portion of the same piece of small intestine, showing the multiple cavities beneath the mucosa; the muscular coat is recognizable at the top of the specimen. (Twice natural size.)

prim nor inconvenience. His bowels acted regularly without an aperient; he had gained 2 stone in weight and resumed his work. Three weeks ago in answer to a letter, he stated that there had not been any recurrence of symptoms and that he was quite well.

For the purpose of investigation a V-shaped piece of the intestine was excised transversely to its long axis so as to leave the mesenteric border intact, the gap being closed with a continuous silk suture (Fig 372). It was sent immediately to Professor Shattock, who reported that—

“Its mucous membrane was raised in rounded, confluent elevations, obviously filled with gas. On the peritoneal aspect the intestine at the particular spot was normal although at first sight the thinness and translucency of the wall led to the belief that the gas cysts were beneath the peritoneum.

(It should be noted that Professor Shattock describes a normal peritoneal covering and submucous cysts, whereas the portion of bowel selected for excision was studded with subperitoneal cysts. The change in the location of the cysts must have been due to the hardening agent, which caused the intestine to curl up and thus drove all the subperitoneal gas into the submucous cavities.)

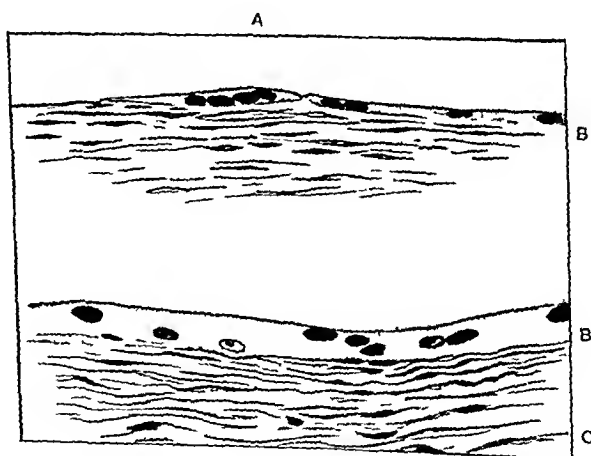


FIG 373—Case 1. Microscopic sections showing the endothelial lining of the cysts. In the upper it is thinner than in the lower and includes a flattened multinucleated cell. The histological signs of inflammation are quite absent. A. Giant cell. B. Endothelium. C. Normal connective tissue ('obj').

‘HISTOLOGY (Fig 373).—Sections cut in paraffin and stained with Ehrlich's haematoxylin and eosin yield the following results. The walls of the spaces, which are limited to the submucosa, consist of ordinary connective tissue in which there is

an utter absence of small-celled infiltration or of any of the marks of inflammation. Their inner surface is lined with a simple endothelium, which is most satisfactorily seen when part of the trabecula is viewed on the flat, the cells form an extremely thin, continuous mosaic, and are furnished with large oval nuclei of the usual type. Here and there a flattened, multinucleated giant cell is intercalated between them. In the connective tissue of the submucosa in the neighbourhood of the cysts, and between the layers of muscle, the strands of sympathetic fibres and the nerve cells of Meissner's and Auerbach's plexuses are particularly distinct and normal. Both the mucosa and the muscular wall are quite intact. Certain of the spaces have a thin wall of connective tissue differentiated from that around by its concentric disposition. The presence of so complete an endothelial lining indicates that the spaces here shown are lymphatic rather than clefts produced by the inflation of the connective tissue, the walls of which have become lined with proliferated lamellar corpuscles."

An attempt was made to ascertain the composition of the gas, but the quantity obtained from the cysts was so small that analysis was impossible.



FIG. 374.—Case 2. Cystic pneumatosis of the cecum and ascending colon. The cecum has been laid open by a vertical incision; the ileum and the ascending colon have been bisected longitudinally. A, Ascending colon showing extensive submucous emphysema. C, Cecum much thickened by gas in the submucous tissue. ICV, Ileocecal valve. I, Normal ileum.

Case 2—A woman, age 40, upon whom I operated on May 27, 1919. She was quite well until twelve days previously, when she was suddenly seized with acute colicky pain in the right iliac fossa. The pain subsided in a few hours, but recurred a week later, and gradually became more intense. There was no vomiting, and only slight constipation. Upon examination, a tender, elongated swelling was found in the right iliac fossa which stiffened and relaxed every few minutes, suggesting an intussusception. There were no signs of peritonitis, the temperature was normal, pulse 72. At the operation the walls of the cecum and ascending colon were found inflamed, thickened, and crepitant on pressure, beads of gas, moreover, were freely distributed in the surrounding connective tissue, and in some of the appendices epiploicæ. The vermiform appendix, and termination of the ileum, were unaffected. There were several calcified tuberculous lymphatic glands in the ileal mesentery, no tubercles were seen on the peritoneum. After excision of the terminal six inches of the ileum, together with the cecum, the ascending colon, and a third of the transverse colon, the continuity of the bowel was restored by lateral ileo-transverse colostomy. Recovery was rapid and uneventful, and she has remained well ever since.

Professor Shattock examined the specimen (Fig. 374)* and reported as

* This specimen is now preserved in the Museum of the Royal College of Surgeons
No. 11421 General Pathological Series

follows "On slitting up the cecum its walls were found thickened throughout from submucous emphysema, the ileocecal valve being also involved the mucosa of the latter was deeply congested, but without ulceration. There was a second patch of congestion, about the size of a sixpence, at the upper part of the cecum. The connective tissue and appertaining fat about the cecum and ascending colon contained large numbers of gas blebs, ranging from a minute size to that of a pea. After the parts had been hardened in formal solution, the examination was completed. The termination of the small intestine was divided longitudinally, the incision being carried through the valve into the cecum, it is remarkably contracted, its mucosa being thrown into regular, closely set, circular folds like *valvula conniventes*. Its walls are quite free of gas, no ulceration is discoverable its

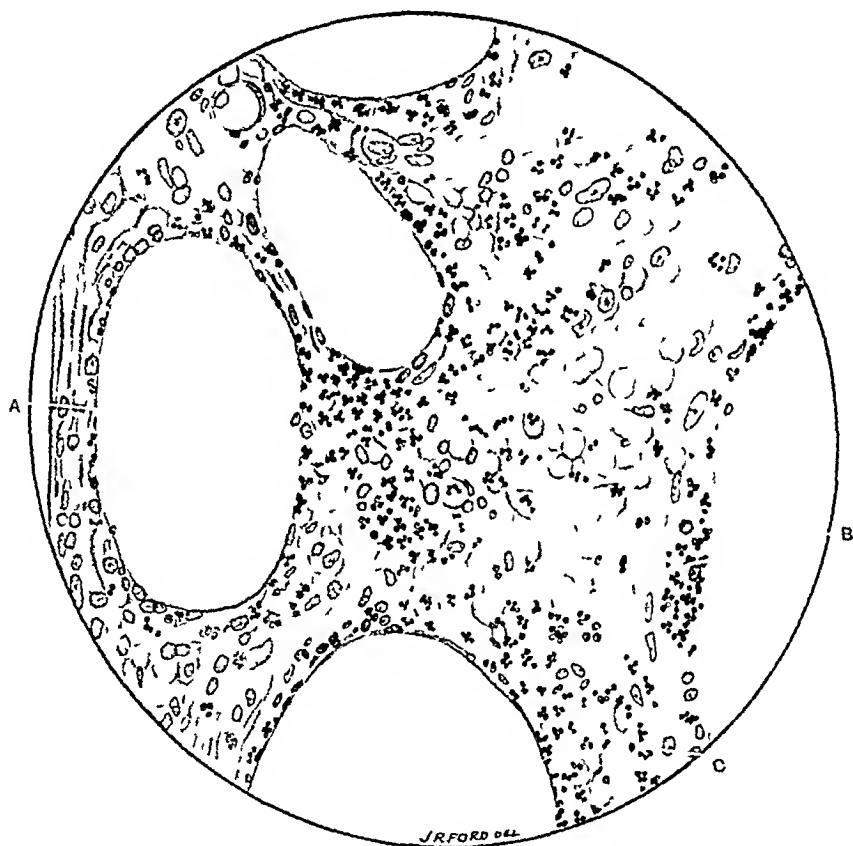


FIG 375—Case 2 A microscopic section of the emphysematous colon, showing the spaces in the submucosa. The septa are thickly infiltrated with polymorphs. In the earlier stages the formation of gas is accompanied with an exudation of serum, as may be recognized in the thickest of the trabeculae. The section is from the neighbourhood of the most distal portion (4 obj). A Large space without differentiated lining B Small space filled with serous exudate C Polymorphs

interior contained a small amount of green, bile-stained mucus. On longitudinally bisecting the ascending colon, a remarkable condition presented itself. The mucous membrane is raised in prominent, somewhat hemispherical elevations by a diffuse submucous emphysema, the tissue being like a sponge, or a section of lung. The elevations are so prominent, and interdigitate so compactly, as to block the lumen. The line of the muscularis is straight and intact, and the mucous membrane itself is readily traceable over the cavernous areas resulting from the pneumatosis. The cecum is similarly, though less, affected, the elevation of the mucosa being uniform

in degree, and so general that the lumen is but slightly diminished. The valve is involved in the same manner, but the condition ceases abruptly at the small intestine. The vermiform appendix, lastly, is firm, and below the normal in diameter. The longitudinal bisection it proved to be solid throughout.

"The microscopic examination of the wall of the ascending colon (Fig 375) in the neighbourhood of the distal end of the emphysematous portion, shows that the mucosa with its glandular structures, as well as the muscularis, are unaffected. The vacuolation is limited to the submucous connective tissue. The smaller spaces are partly filled with homogeneous exudate containing polymorphs, large numbers of which infiltrate the septa between the lacunae. The spaces have no differentiated lining. Sections prepared from the emphysematous ileocaecal valve exhibit similar appearances, in these there are conspicuous numbers of multinuclear giant cells in the tissue bounding the spaces.

"In this case there was no obstruction, either distal or proximal to the affected area, which might have resulted in hyperdistention and trauma of the mucosa, nor was there any ulcer the base of which might have given way and allowed of the effusion of gas. The emphysema cannot but be ascribed to an infection of the wall of the caecum with a gas-producing bacillus, notwithstanding the failure to demonstrate the presence of such in histological sections, either in the exudate or in the cells. The histological picture is that of a somewhat acute infective process which involves not only the submucosa, but in places, the muscularis also. There are no vacuoles in the giant cells to suggest that these are gas-secreting, and it may be observed that giant-cells are not present in the proper gas-gland of the swim-bladder of fish."

The rareness of this condition is exemplified by the fact that within the last two centuries only about 90* cases have been recorded, one in Scotland (Shennan and Wilkie, 1909) four in England, including the two just described (Man 1, Thorburn 1, Nitch and Shattock 2), four in America (Finney 1, Twyman 1, Bubis and Swanbeck 1, Sloan 1), and the remainder abroad.

HISTORICAL

Probably the earliest known specimen is one described in the catalogue of Ruysch's Anatomical Museum in Amsterdam in 1737 as "a portion of the jejunum of a man showing a tumour which arose from wind when the external tunica was slightly injured."

Ten years later, in 1747, Combalusier, in his work on pneumatosis, cited an observation by an anonymous writer (I G D — ? Duvernoy) in the *Académie Scientiarum Petropolitane* (St Petersburg) *Tomus v*, p 213 (1730-31), on the presence of subperitoneal and submucous collections of gas in the intestine. These swellings were "alike in number, shape, and size, some being narrow and some cneular, and some projected to such an extent that they almost obliterated the lumen of the canal."

In 1756 Haller found numerous subperitoneal gas cysts on the intestines of a woman who died of tympanites. The condition apparently attracted no further notice or was not considered worthy of comment, for 64 years, when Cloquet in 1820 reported a case of emphysema of the wall of the stomach in a male discovered a few hours after death, and Andral in 1831 drew attention to a similar condition which he had noted at autopsies performed in the summer

* The number is given at about 90 for though only 85 have been traced, the writer thinks some have escaped his notice.

shortly after death. Both writers realized that post-mortem decomposition might account for the emphysema, but evidently the appearance was not quite similar, for in commenting on it, they each stated that though discovered at an autopsy it might have formed during life. They also pointed out the macroscopic resemblance between intestinal pneumatosis in man and gas cysts found in the rectum of hogs slaughtered in summer.

A somewhat similar condition known as *vaginitis emphysematosa* was first described by Ritgen in 1835 and subsequently by Winckel in 1871. It is characterized by the presence of gas cysts in the mucosa and submucosa of the upper part of the vagina and occasionally also in the bladder in pregnant women or after parturition in women the subjects of gonorrhœa and is now ascribed to infection of inflammatory nodules by a gas-forming organism, the *B. aerogenes*. Chian, writing in 1885 connected the disease with intestinal pneumatosis. This opinion was upheld by Eppinger and Eisenlohn (1888) who found gas cysts in the intestine of a case of *vaginitis emphysematosa* which was examined four and a half hours after death from heart disease. Owing to the presence of groups of bacilli in the cysts they considered that both diseases were due to bacterial infection. In view of recent research, it is probable that the bacterial infection of the intestinal cysts in these cases was post- rather than ante-mortem.

After Andral's brief communication in 1831, there does not appear to be another record of human intestinal pneumatosis until 1876, when Bang, of Copenhagen described an undoubted case which attracted so much attention that he was erroneously credited with the discovery of the disease. At an autopsy on a woman, age 57, who died of volvulus of the sigmoid, Bang found multiple gas cysts varying in size from a pea to a bean, in the wall of the lower two feet of the ileum. The cysts were in the submucosa and between the circular muscle fibres, they were lined with endothelium, and their walls contained numerous giant cells. He considered that they were due either to dilatation of lymphatic spaces or to a neoplasm, he called the disease *pneumatosis cystoides intestini hominis*, a name which Continental writers have retained. In a paper on cysts of the intestine published in 1882, Marchiasava described a case which in the extent and distribution of the cysts closely resembles one of mine (Case 1). At an autopsy after dysentery the whole of the small intestine, with the exception of the first part of the jejunum, was found to be studded with subserous gas cysts containing many multinucleated giant cells in their walls. The presence or absence of an ulcer of the stomach or intestine is not mentioned.

Up to this time all the records relate to findings at post mortem examinations, and it was not until 1899, when abdominal surgery had become a regular procedure, that Hahn described the first case of cystic pneumatosis discovered in the living. At an operation for supposed pyloric stenosis on a male, age 35 the subject of abdominal pain and alternating constipation and diarrhœa of two years' duration he found a large number of sessile and pedunculated gas cysts on the small and large intestine. The pylorus was said to be patent but the stomach and ascending colon were greatly dilated.

Since then the number of recorded cases has gradually increased. Faltin, in 1914, described 55 cases, of which 33 were discovered at operation, a year

later Kudei published 62, in 1920 Hey, and at a later date Weil, each added 4 cases making 70 in all, of which about two-thirds were noted at operation, and finally after a prolonged search through a voluminous literature, I have found 15 more, bringing the total to 85. In all probability this number is fairly accurate for these cases are so rare that they seldom escape publication.

INTESTINAL EMPHYSEMA OF SWINE

An analogous condition called intestinal emphysema occurs in certain animals, and is similar in many respects to cystic pneumatosis of man. It is found comparatively frequently in the intestine and rectum of swine killed



FIG 376.—Hunterian Specimen No 11411, Museum Royal College of Surgeons. Portion of hog's rectum with subperitoneal gas cysts. Many are pedunculated and also twisted on their pedicles.

in the summer and has been the subject of much investigation and argument. First noted by Andral in 1825, it was more carefully investigated in the same year by Mayer who concluded that it was due to the mechanical escape of gas into the submucous and subserous tissues through an abrasion in the mucous membrane. In 1837, John Hunter also drew attention to the presence of gas cysts on the intestines of hogs killed in summer and suggested that the air escaped from the blood either from natural causes or through diseased vessels. Two of his specimens, Nos 11411 and 11412 are in the Hunterian Collection in the Museum of the Royal College of Surgeons and one of them *Fig 376*, is thus described: "A portion of the rectum of a hog, of which the peritoneal coat is in many places, and especially by the sides of the mesorectum covered with clusters of thinly walled cysts, many of which are pedunculated, and all of which contained gas."

This specimen is illustrated in Hunter's *Works*, where it is recorded that it was sent to him by Jenner and that the gas in the cysts was examined by Cavendish, who found "it contained a little fixed air (carbon dioxide), and the remainder not at all inflammable (inflammable air = hydrogen) and

almost completely phlogistigated" (phlogistigated air = nitrogen). Sir James Paget commenting on this specimen in his *Letters on Surgical Pathology* third ed 1870, p 402, thus eulogizes: "What a relic have we here! Surely never on an object so mean to common apprehensions, did such rays of intellectual light converge as on these to which were addressed the frequent and inquiring observations of Jenner, the keen analysis by Cavendish and the vast comparison and deep reflection of John Hunter! Surely never were

the elements of an inductive process combined in such perfection! Jenner to observe, Cavendish to analyse, Hunter to compare and reflect."

The first detailed description of intestinal emphysema of swine was published by Roth who stated that both the macroscopic and the microscopic appearances were very similar to those of the human variety. Subsequently Schmutzer and Heydemann confirmed his findings and together with Plenge, agreed with his conclusion that the gas in the cysts was intestinal in origin. This view is strongly opposed by Dupraz, Jaeger and more recently by Joest. They consider that the gas is bacterial in origin though they do not agree on the organism concerned in its production. Jaeger cultivated a gas-forming bacillus of the coliform group from some of his cases, which he named *B. coli lymphaticum aerogenes*, and on the basis of animal experiments concluded that the bacilli entered the submucous lymphatics through a chronically inflamed mucous membrane. Joest, in supporting this view, points out that it is impossible for intestinal gases to enter the lymphatics by intestinal pressure alone, and that, in pigs affected with emphysema, obstruction with distention of the intestines has never been observed. He refers to the frequency of the disease in dany-fed pigs in which intestinal catarrh from an excessive carbohydrate diet is of common occurrence, and suggests that colon bacilli enter the chyle ducts through the inflamed mucous membrane, where their fermentative action on an excess of sugar leads to the formation of gas.

According to Finney, the bacterial origin of the disease in pigs was confirmed by investigations carried out in America, where a colon bacillus was isolated in every case examined. The similarity of the gas, i.e., atmospheric air in both human and animal cysts, is explained by diffusion through the cyst wall in the long interval which often elapsed between the removal of the specimen and the analysis of the gas (Jaeger).

Although intestinal emphysema in man and animals is in many ways much alike, Jaeger draws attention to dissimilarities which strongly suggest a different pathogenesis. Notably, in man, pneumatosis is usually more widely distributed than in the pig affecting the colon, cæcum, small intestine, and even the stomach, while the cysts are most numerous on the ante-mesenteric surface of the bowel. In pigs, the disease is usually limited to the jejunum, rectum, and mesentery, and the cysts are practically always situated at the attachment of the mesentery. Again in man, pneumatosis is nearly always associated with constipation and an organic stricture of some portion of the intestinal tract, whereas, in pigs, intestinal catarrh is the only lesion that has been discovered.

After this brief digression into the realms of comparative pathology, I will return to pneumatosis of man.

PNEUMATOSIS IN MAN

Co-existing Lesions—As already stated at the time of writing, records of 85 cases only have been found. In 29 the lesion was discovered at a post-mortem examination, and it is significant that in 9 of these, or 31 per cent death was due to one of the complications of gastric or duodenal ulcer. Of the remainder, 52 were detected at an operation, and again the commonest lesion was a gastric or duodenal ulcer (34, or 65 per cent).

Therefore, in the 85 cases, 43 (50 per cent) were with an ulcer of the stomach or duodenum, and in 36 of these (83 per cent) there was stenosis. Other co-existing lesions of importance were carcinoma of pylorus (2) tuberculous ulceration of the intestine (4) intestinal obstruction (3) tuberculous peritonitis (1), and gastro-enteritis (2). In 21, morbid anatomy in addition to the gas cysts were either not found or not recorded.

Sex and Age—Males are affected more often than females, in a fact which has an important bearing on their etiology. The ratio of about 3 to 1, and the age limit ranges between 13 and 60 years. In 37 cases the age incidence was as follows: 10-20, 1; 20-30, 5; 30-40, 14; 40-50, 10; 50-60, 6; 60-70, 1. Thus it is commonest in the fourth and fifth decades—the ages for chronic gastric and duodenal ulcers. In an analysis of 45 cases the lesions were distributed as follows:

Situation—In an analysis of 45 cases the lesions were distributed as follows:—

Stomach,	gastro colic and gastro hepatic omentum (cerc pylorus)	1
"	Jejunum, ileum, transverse and ascending colon (pyloric stenosis)	1
Pyloicus only (stenosis)		1
Jejunum	only (pyloric stenosis)	4
"	parietal peritoneum and diaphragm (peritonitis)	1
"	and ileum only (pyloric stenosis 3, intestinal obstruction 1)	3
"	ileum, great omentum, and diaphragm (pyloric stenosis)	1
"	and great omentum (pyloric stenosis in all)	1
"	and transverse mesocolon (pyloric stenosis)	1
"	cæcum and ascending colon	1
"	ascending colon, transverse mesocolon, and great omentum	1
"	ascending and transverse colon (pyloric ulcer)	13
"	ascending stenosis 13, cerc pylorus 1, volv sigmoid 1)	1
Ileum	only (pyloric stenosis)	1
"	and gastro hepatic omentum (pyloric stenosis)	1
"	and transverse mesocolon (pyloric stenosis)	1
"	and great omentum	1
"	and vagina (probably post mortem)	1
"	and cæcum	1
"	cæcum and ascending colon	2
"	transverse mesocolon, and great omentum	1
"	and ascending colon (pyloric stenosis)	1
Cæcum	and appendices epiploice	1
"	and ascending colon (pul phthisis 1, appendicitis 1)	1
"	ascending colon, and appendices epiploice	1
Hepatic flexure	(adherent to stenosed pylorus)	1

always situated on some portion of the intestine
The jejunum is always near its termination. It is rare to find cysts
in the jejunum. Cysts have been found in the duodenum.

" and ascending colon (pul phthisis 1, app-
 Cecum and appendices epiploicæ
 " and ascending colon (pul phthisis 1, app-
 " ascending colon, and appendices epiploicæ
 Hepatic flexure (adherent to stenosed pylorus)

The cysts are always situated on some portion of the intestine, and most often on the ileum, particularly near its termination. The jejunum is frequently involved as well as the ileum, but it is rare to find cysts on this portion of the bowel alone. In only one instance have cysts been described on the duodenum (Kolli, quoted by Plenge), otherwise, this segment of bowel shares with the appendix and rectum a remarkable freedom. The large bowel is affected with comparative frequency, when the cyst formation appears to cease abruptly at the splenic flexure, it is seldom involved alone, being usually associated with similar lesions in the lower end of the ileum. In some instances the emphysema is limited to the cæcum and ascending colon, and in four such cases the presence of a definite tumour before operation led to a diagnosis of intussusception or appendicitis. It is noteworthy that in

three of these cases (Philip, Twyman, Nitch) there was no lesion to account for the cysts, and in the fourth (Bubis and Swanbeck) there was an ulcer

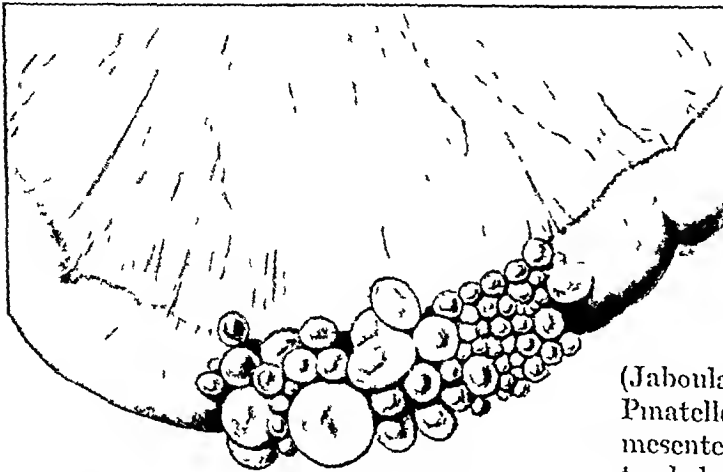


FIG 377—Showing clusters of gas containing cysts on the small intestine (From a photograph of an illustration in *Annales de Medecine*, 1920 in article by M P Weil Illustration lent by Mauclair)

at the base of the appendix The stomach omentum mesenteric peritoneum and appendices epiploicae are rarely affected In two cases a cluster of cysts was found on the under surface of the diaphragm (Jaboulay, and Vallas and Pmatelle) in another the mesenteric glands were distended with gas bubbles (Schnyder) and in another rows of cysts were found in the mesenteric lymphatics (Jaeger)

Though the cysts are usually situated opposite the attachment of the mesentery, they may be more or less uniformly distributed over the whole surface of the intestine, and also on the mesentery itself As a rule they are spread over a considerable length of intestine as in my first case but they may occur in large or small groups separated from each other by portions of healthy bowel (Fig 377) They sometimes form masses, like a collection of soap bubbles or a bunch of translucent grapes, attached to the convex surface of the intestine (Fig 378), and in one case described by Neugebauer formed a large tumour which could be both felt and seen beneath the abdominal wall Though usually sessile, they may possess pedicles as long as 5 cm (Plenge) which are sometimes twisted on their long axes as in John Hunter's specimen of the hog's rectum (Fig 376) As a

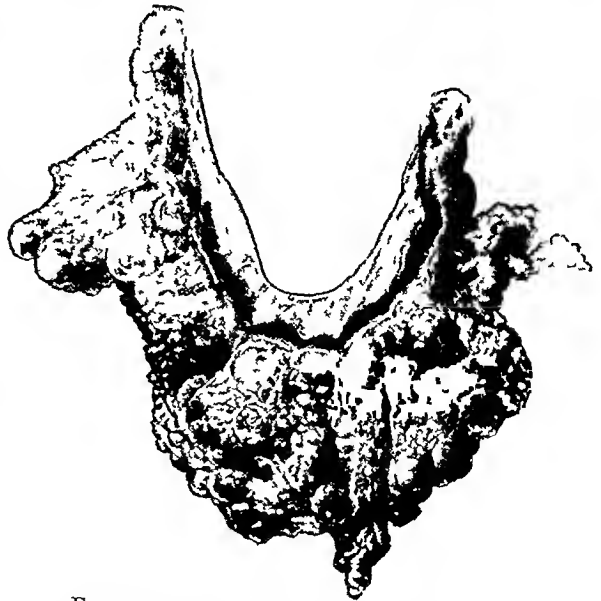


FIG 378—Sloan's case Masses of translucent gas containing cysts attached to the convex surface of the small intestine (Photograph from an illustration in *Surgery Gynecology and Obstetrics*, 1920, xxx, 390)

As a

general rule the single cysts, as distinct from the massed collections, vary in size from that of a pin's head to that of a walnut, but Aitz has described one as large as an egg, and Urban one the size of a man's fist.

Small white raised papules on the surface of the intestines, probably due to collapsed cysts, have been noted by several observers (Bang, Faltin, Plenge, Winands, Urban). Curious villous tufts of uncertain origin are also sometimes present between the subserous cysts both in man and pig, they have been variously ascribed to hyperplasia of the endothelial lining of the lymphatics (Roth, Bang), and to strands of subserous connective tissue which have followed the migration of gas beneath the peritoneum (Schmutze).

The anatomical site of the cysts of the intestine is the subserous and submucous tissues, they are seldom found in the muscular coat and have only been seen in the mucosa on two occasions (Heydermann). Beneath the peritoneum they form oval and rounded, shiny, translucent swellings, which are occasionally globular and pedunculated, in the submucosa, owing to the thickness of the mucous membrane covering them, they are not translucent and never pedunculated. They are seldom limited to one tunic alone, in some instances the greatest number were subserous, and in others submucous. Olandi records one case in which they had encroached on the lumen of the bowel to such an extent as to produce obstruction. They rarely communicate with each other or directly with the interior of the intestine, but Bubis and Swanbeck record the interesting observation that, in a case of emphysema of the cæcum with an ulcer at the base of the appendix, compression of the cæcum caused gas to escape through the ulcer.

In two of the cases of pneumatosis of the cæcum (Bubis and Swanbeck, and Nitch) the condition was analogous to a true surgical emphysema, for the gas, instead of forming localized collections, had permeated the tissues to such an extent as to give them the appearance of a sponge, or a section of lung. It may be mentioned here in passing, that in the writer's opinion this form of emphysema bears no relationship to the classical form of cystic pneumatosis, though it is often included in the same category.

Histology—All writers agree as to the remarkable uniformity of the histological appearances. The wall of the cyst is always the same, consisting of ordinary connective tissue of varying thickness in which there are no signs of small-celled infiltration or inflammation (Figs 373-379). The vessels in the walls are small and few in number. Turnure, Kudei, and Urban describe a perivascular round-celled proliferation between the cysts, and Torraca noted a similar change around the lymphatics. The cysts are lined with a simple endothelium containing a varying number of multinucleated giant cells. In some sections examined by Plenge this lining membrane was covered with giant cells with pseudopodic processes which projected into the cavity of the cyst, and he also noted giant cells of uncertain origin in the inter-cystic connective tissue. Mattona points out that pseudopodic processes are only seen in small cysts where the gas tension is slight, and that as the walls yield to increasing pressure the giant cells become flattened and scanty and in the largest cysts, extremely rare. Retrogression of the cyst is characterized by increase of its concentric connective tissue and progressive decrease of its lumen until it is reduced to a nodule of compact fibrous

tissue, forming the raised white papule or 'seal' so commonly seen beneath the peritoneum

The constant presence of giant cells in the walls of the cysts has led some writers to credit them with a pathogenic rôle thus Mann considered that by a process of vacuolation within them the nodules of dense connective tissue in which they were imbedded became hollowed out to form cysts, Shennan and Wilkie and others have suggested that they are concerned with the production of gas. In this context it should be noted that there are no giant cells in the gas-gland of the swim-bladder of fish. The fact that giant-celled formation is now well recognized by pathologists as a sign of chronicity is a sufficient and simple explanation of their presence in the cyst wall. Fissures containing gas, either with or without an endothelial lining are occasionally found in the muscular coat the former are due to enlargement of a lymphatic

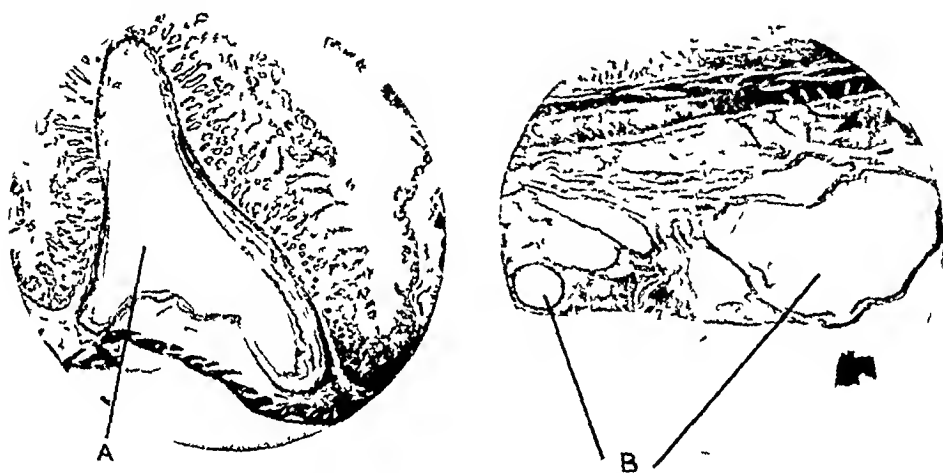


FIG. 379—Shennan and Wilkie's case

A Section from upper portion of ileum with a submucous cyst projecting into lumen of bowel. It is quite separate from the muscular coats and is partly lined by flat tenured multinucleated cells (a). At (b) is a narrow cyst lined by similar cells ($\times 18$)

B Section from lowest affected coil with cysts on the serous surface, showing a recent cyst with lining giant cells and a fully formed cyst, with scanty flat lining cells ($\times 10$)

(From the 'Journal of Pathology and Bacteriology', 1909, vii)

space (Ciechanowski, Hey), and the latter to escape of gas into the surrounding connective tissue from a ruptured cyst. In rare instances the cysts contain, in addition to gas, a small quantity of serous fluid which is remarkable for its lack of cells. Gelatinous masses of blood-stained fluid of obscure origin have also been noted. A constant feature of the histological picture in a large proportion of the cases has been a chronic hyperplastic endolymphangitis, a fact which combined with so complete an endothelial lining to the cysts leads to the inevitable conclusion that these gas-containing spaces are formed in lymphatics rather than in clefts in the connective tissue.

In the type of pneumatosis in reality an emphysema, represented by my second case the cysts had no differentiated lining, and the smaller spaces were partly filled with a homogeneous exudate containing polymorphs, large numbers of which were also in the septa between the lacunae (Fig. 375)

Bacteriology—Bacteria have rarely been seen or cultivated in typical examples of cystic pneumatosis. Positive findings in considerable variety have usually been obtained from cadavres, but cultures from fresh specimens have nearly always proved negative. The absence of small-celled infiltration alluded to above is also strong proof of the non-existence of bacteria. Though cultures were not taken from my specimens examination of a series of specially-stained sections by Professor Shattock failed to reveal any micro-organisms either in the walls of the cysts or in the tissue around. In the second case the histological picture (Fig 375) of an acute infective process led him to ascribe the emphysema to an infection with a gas-producing bacillus. In the few cases in which a careful bacterial investigation of fresh tissue has been made the results have been very varied. Hahn found cocci, Jaeger isolated an organism of the colon group which he named the *B. coli lymphaticum aerogenes*, Schnyder and Schonberg grew a similar organism. Muva found a gas-forming bacillus which grew well on sugar, but animal inoculation was negative, Norwick considered that the colon bacillus he isolated was due to contamination, Dupiaz found a colon bacillus and a Gram-negative coccus, which when mixed with lactic acid and sprayed into the vagina of dogs produced gas cysts, Shennan and Wilkie obtained a pure culture of *B. coli communis*, and Steindl isolated a Gram-positive bacillus.

The different histological appearances mentioned above, combined with the occasional isolation of a gas-forming bacillus from the material collected at the time of operation, strongly suggest the existence of two distinct varieties of cystic pneumatosis, each with a different pathogenesis. If this view be accepted, it explains many of the difficulties which writers have experienced in accounting for the origin and cause of the cysts.

Composition of the Gas—The gas has been analysed on several occasions, but unfortunately the results have not always coincided, probably owing to the difficulty of obtaining a volume large enough for accurate calculation, and to the rapidity with which diffusion takes place through the thin cyst wall. That diffusion has an important bearing on the results of analysis was proved experimentally by Jaeger, who found that the interchange of gas in a tied coil of intestine and the air was complete in three hours.

On the whole, the composition of the cystic gas has been found to resemble closely that of atmospheric air consisting of O 10 to 16 per cent, N 84 to 90 per cent and CO₂ 0.3 per cent (Krummacher).

	COMPOSITION OF GAS			
	O	H	N	CO ₂
	1 per cent	1 per cent	Per cent	1 per cent
	10-16		84-90	0.3
Cystic Gas (Krummacher)	15.4	0.6	80	4
" " (Urban)	5	73	61	15
Intestinal Gas (Ellenberger)	0.5	14	45	40

Jaeger arrived at a different result, viz O 5.6 per cent, N 61 per cent, CO₂ 15 per cent, and H 73.3 per cent, and concluded on the basis of his

experiment with the coil of intestine that earlier analyses were incorrect, but even his gas differs greatly from intestinal gas, the composition of which as given by Ellenberger, is O 0.5 per cent N 15 per cent CO₂ 10 per cent H₂ 14 per cent. Therefore in his case the gas in the cysts certainly did not emanate from the intestine.

The most reliable analysis is recorded by Urban who obtained the gas by puncture of the abdominal cavity in a remarkable case. His patient, a boy, age 13, with a history of peritonitis at 5½ had suffered from colic vomiting and distention for three years, which was diagnosed as tuberculous peritonitis. At the operation, instead of tubercle, an extensive cystic pneumatosis of the small intestine, caecum, and ascending colon was found. The cysts varied in size from a pea to a nut. Nothing was done, and the abdomen was closed. Seven weeks later, on re-opening the abdomen for excessive distention, a large quantity of odourless gas escaped and the only cysts to be found were on a segment of ileum 50 cm long. The others had disappeared, and their sites were occupied by small gravel-like nodules the remains of collapsed cysts. The affected segment of ileum was short-circuited. On two occasions one month and two months after this operation, the abdomen became greatly distended and was tapped, ¾ litre of gas being evacuated on each occasion which was presumed to have escaped from a ruptured cyst. After this, recovery was rapid and uneventful. The gas obtained at the tapplings was collected and analysed immediately by a chemist, who found it contained O 15.4 per cent, N 80 per cent, CO₂ 4 per cent, and a small quantity of H₂.

Etiology—The various theories which have been advanced to explain the etiology are —

1 *The Neoplastic Theory*

Bang considered that the cysts were formed by central degeneration of a new growth, and that the gas was secreted from the blood as in the swim-bladder of fish. Man thought that the cysts arose in a true neoplasm, and credited the giant cells in their walls with the power of secreting gas. He also considered them analogous to the swim-bladder of fish. Funney, supported by Welch, inclines to the view that the condition is due to a distinct variety of tumour whose cells have the power of secreting gas. Kouskow, in advocating the neoplastic theory, regards the giant cells as specific formers of gas. Very few facts are required to refute this theory. In the first place, the cysts tend to disappear spontaneously leaving in many cases a typical cicatrix, as has been proved at subsequent operations in several cases. Secondly, no analogous gas-containing tumour has yet been described in any other part of the body. Thirdly, gas cysts in connection with carcinoma (of the pylorus) have only been reported in two cases and lastly the microscopic appearances do not bear the least resemblance to those of a neoplasm.

2 *Bacterial Theory*

Many writers believe that bacteria are the cause of the tissue changes and the gas. Their names and the organisms they have found have been enumerated in a preceding paragraph. It is quite natural to attribute the process to gas-forming organisms, and this accounts for the variety that have been suspected. Dupraz and others considered that bacteria gained access to the lymphatics through abrasions in the mucous membrane, and there formed

emboli which led to dilatation of the ducts. Continued growth of the organism was followed by gas-formation and conversion of the duct into a gas-containing cyst. Many of the earlier writers (Eisenlohn, Hahn, Winands, Jaboulay, Jaeger, and others) were strong advocates of the bacterial theory, and quite recently Steindl and Mattona have revived it. The latter suggests that a toxic process leads to obliteration of the lymphatics where fermentation of lymph by some 'rare germ' leads to the formation of gas cysts.

There are many facts which are opposed to the bacterial theory in the majority of cases such as the absence of all signs of inflammation in the cysts and in the tissues surrounding them, the absence of lymph on the surface of the bowel and of adhesions to adjacent coils, the absence of profound toxic symptoms which would be inevitable considering the length of the intestine often involved and above all the failure to discover a specific organism. Joest, in comparing intestinal emphysema of swine with cystic pneumatosis of man, points out that the mere presence of bacteria in the intestinal lymphatics does not necessarily imply that they are the cause of the gas. For this to take place two factors are necessary: (a) the organism must be capable of fermenting carbohydrates, and (b) there must be an excess of carbohydrates in the lymphatics. It might well be argued that as an organism of the colon group is the one most likely to be found in the intestinal lymphatics, Joest's postulates are in favour of the bacterial theory, were it not for the fact that von Meising has shown that under normal conditions carbohydrates are absorbed by the blood-vessels and not by the lymphatics. Finally, Plenge, in refuting the bacterial theory, points out that as the cystic gas generally contains 16 to 20 per cent of oxygen, the microbe must be an oxygen-former, a property which is not possessed by well-known types of gas-producing organisms. He emphasizes the fact that the usual gaseous products of bacterial action on the tissues are carbon dioxide, nitrogen, hydrogen, sulphuretted hydrogen and marsh gas, but never oxygen, and considers, therefore, that the presence of oxygen is strong evidence against this theory.

3 Mechanical Theory

Although there are many facts which are difficult to explain, the majority of investigators now attribute cystic pneumatosis to mechanical causes. They agree in supposing that air is forced under high pressure into the wall of the intestine through an abrasion in the mucous membrane whence it enters the lymphatic network and is driven along the bowel both by the *vis a tergo* of constant pressure and by intestinal peristalsis. Cyst-formation is due to an obliterating endolymphangitis from irritation set up by the gas, and is seen at its best in the loose subserous and submucous connective tissue. The giant cells in the wall of the cysts are also due to irritation.

The association of cystic pneumatosis with a gastric or duodenal ulcer in quite 50 per cent of recorded cases and with an obstructive lesion in some part of the gastro-intestinal tract in over 70 per cent, is greatly in favour of a mechanical cause, especially when it is remembered how rapidly an extensive subcutaneous emphysema may follow a comparatively minute injury in other parts of the body.

The conditions in the intestinal tract are similar, for together with an established atrium in the form of an ulcer, the majority of patients give a

into the lumen of the bowel. In the great majority of cases, after treatment of the co-existing disease the cysts disappear spontaneously. This has been proved on several occasions by Kadjan, Moir, Urban, Faltin, and others, at a second operation when the cysts were found to have disappeared either wholly or in part. The cysts should never be crushed or punctured owing to the danger of subsequent perforation of the weakened intestinal wall. Enterio-anastomosis should rarely be necessary, and resection is only required where a mass of submucous cysts are causing obstruction, or in the type of bacterial emphysema illustrated by my second case.

Duration and Prognosis.—Except in cases of bacterial emphysema, the duration of the condition, from its commencement to the time of its discovery at an operation, is variable and uncertain, for any symptoms it may give rise to are masked by those of the primary disease. Also, unless the upper coils of intestine are carefully examined for the scars of collapsed cysts, a collection on a lower coil might be considered a recent formation, whereas in reality the gas in it has only been slowly driven along the intestinal wall, passing the fibrous remains of collapsed cysts and obliterated lymphatics on the way.

The prognosis is uniformly good, provided the primary disease is treated efficiently.

The diverse and often contradictory results of bacteriological investigations and of gas analyses have led to much confusion. In the writer's opinion there are two definite groups of intestinal pneumatosis: (1) the cystic and mechanical variety—the one most often seen and described—and (2) the less frequent form due to infection by gas-producing organisms. The two cases reported at the beginning of this paper fall naturally into these groups.

In *Case 1*, where there was definite pyloric stenosis and where the cysts were more or less evenly distributed over a great length of intestine, there was not the least sign either clinically or microscopically of a bacterial infection. The patient had no pyrexia, toxic symptoms, or symptoms referable to the cysts which might have been expected in so extensive a lesion had gas-producing organisms been the exciting cause. Moreover, sections specially prepared and stained from material removed at the operation, and placed immediately in a hardening solution, showed a complete absence of bacteria or inflammatory changes. The lesions in this case, which is similar to the majority of cases described by other writers, are best explained by the mechanical theory.

Case 2 on the other hand differed clinically, macroscopically, and microscopically. A definite tender tumour was palpable through the abdominal wall, the disease was limited to the large intestine, where gas-producing organisms flourish, the walls of the bowel were thickened and inflamed, and on section the emphysema was found to be limited to the submucosa and similar in many respects to the subacute form of emphysematous cellulitis complicating a wound infected with *B. coli* or an attenuated *B. aerogenes*. Microscopically the spaces had no endothelial lining, and both they and the tissue between them contained large numbers of polymorphs, a typical picture of a somewhat acute infective process caused by a gas-forming micro-organism.

TABULATED LIST OF 85 RECORDED CASES

No	AUTHOR	YEAR	COEXISTING LESION AND REMARKS	DISCOVERED AT OPERATION OR POST MORTEM
1	Bang	1876	Death from volvulus of sigmoid	Post mortem
2	Marchiafava	1882	Pyloric stenosis	, ,
3	Eisenlohr	1888	Death from heart disease	, ,
4	Camargo de	1891	Death from pulmonary tuberculosis	, ,
5	Kouskow	1891	Gastric ulcer	, ,
6	Winands	1895	Chronic gastric ulcer	, ,
7	Kolli	1895	Gastric ulcer	, ,
8	Orlandi	1896	Death from intestinal obstruction	, ,
9	Dupriz	1897	{Intestinal tuberculosis in one case Pernicious anemia in another }	, ,
10				
11				
12				
13	Hahn	1899	Dilated stomach and ascending colon ? Gastric ulcer	Operation
14	Korte	1899	Pyloric ulcer and stenosis	Post mortem
15	Wickerhausen	1900	, , , ,	Operation
16	Troublay and Tolot	1901	, , , ,	, ,
17	Vallas and Pinatelle	1901	None	, ,
18	Mura	1901	Gastric ulcer and stenosis	Post mortem
19	Verebely	1901	Intestinal tuberculosis	, ,
20	Kadjun	1902	Tuberculous peritonitis	Operation
21	Thorburn	1902	Pyloric ulcer and stenosis	, ,
22	Nigrisoli	1902	, , , ,	, ,
23	Von Hicker and Von Hibler	1903	Perforated gastric ulcer	, ,
24	Ciechomowski	1904	Gastric ulcer with stenosis	Post mortem
25	Stori	1904	Pyloric ulcer and stenosis	Operation
26	, ,	1904	Pyloric stenosis	, ,
27	Visconti	1904	, , , ,	, ,
28	Lubarsch	1906	No clinical details	Post mortem
29				
30	Mori	1907	Pyloric stenosis	Operation
31				

TABULATED LIST OF 85 RECORDED CASES—*continued*

No	AUTHOR	Year	COEXISTING LESION AND REMARKS	DISCOVERED AT OPERATION OR POST MORTEM
32	Muir	1907	Pyloric stenosis	Operation
33	Mitchell	1907	, ,	"
34	Grondahl	1908	Duodenal ulcer and stenosis	Post mortem
35	Finney	1908	Carcinoma of pylorus	Operation
36	Herman	1908	?	Post mortem
37	Nowicki	1909	Gastro enteritis	" "
38	"	1909	Heart disease	" "
39	"	1909	Pulmonary tuberculosis	" "
40	Woltman and Wasiljew	1909	No coexisting lesion discovered pre- vious operation for appendicitis	Operation
41	Jamainouchi	1909	Pyloric ulcer and stenosis	"
42	Shennan and Wilkie	1909	Pyloric stenosis	"
43	Wiesinger	1910	Chronic intestinal obstruction by adhesions	"
44	Urban	1910	No coexisting lesion found	"
45	Arzt	1910	Pyloric stenosis	"
46	Simmonds	1910	Gastric ulcer	"
47	Martini	1910	Pyloric stenosis	"
48	Neudorfer	1910	Pyloric ulcer	"
49	Ciechanowski	1911	No details	?
50	"	1911	, ,	?
51	Myake	1911	Chronic appendicitis	Operation
52	Philip	1911	No coexisting lesion discovered	"
53	Bindi	1912	" " " "	Post mortem
54	Cilli	1912	?	Operation
55	Uchino	1912	?	"
56	Turnure	1913	Perforated gastric ulcer	"
57	Lejars	1913	Pyloric stenosis	"
58	Barjon and Dupiquier	1913	Gastric and pyloric ulcers	"
59	Macleure	1914	Pyloric stenosis	"

TABULATED LIST OF 85 RECORDED CASES—continued

No	AUTHOR	YEAR	COEXISTING LESION AND REMARKS	DISCOVERED AT OPERATION OR POST MORTEM
60	Neugebauer	1914	Tuberculosis of cecum	Operation
61	Demmer	1914	Pyloric stenosis	"
62	Warstat	1917	Pyloric ulcer and stenosis	Post mortem
63	Schnyder	1917	Death from uremia	" "
64	"	1917	Death from diphtheria and myocarditis	" "
65	Moreau	1917	?	?
66	Kuder	1918	Carcinoma of pylorus	Operation
67	Mathieu Pierre Weil	1919	Dilated stomach No pathological lesion	Operation and post mortem
68	Tuffier	1919	Pyloric stenosis	Operation
69	Letulle	1919	Intestinal tuberculosis	Post mortem
70	Cristol and Porte	1919	No coexisting lesion	Operation
71	Lafoucade	1919	Pyloric ulcer and stenosis	"
72	Nitch and Shattock	1919	Pyloric stenosis	"
73	" " "	1919	No coexisting lesion	"
74	Fwyman	1919	? Appendicitis	"
75	Hey	1920	Pyloric ulcer and stenosis	"
76	Alessandrini	1920	Pyloric stenosis	"
77	Sloman	1920	" "	"
78	Torraca	1920	?	?
79	Plenge	1921	Pyloric stenosis	Operation
80	"	1921	" "	"
81	Stendl	1921	No coexisting lesion discovered	"
82	Warrach	1922	Pyloric ulcer and stenosis	"
83	Bubis and Swanbeck	1922	Ulcer at base of appendix	"
84	Schulte	1922	Duodenal ulcer	"
85	Matronali	1922	Pyloric stenosis	"

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OSTEOGENESIS IMPERFECTA

BY R. LAWFORD KNAGGS, LONDON

(Being the Hunterian Lecture delivered at the Royal College of Surgeons of England
on Feb 13, 1924)

OSTEOGENESIS imperfecta is the name given to a disease which is characterized by a congenital defect in the evolution of the osteoblast, and recognized clinically by defective ossification of the cranium and a multiplicity of fractures resulting from trivial causes.

Cases, now recognized as instances of this affection, are scattered throughout literature under such titles as foetal rickets, idiopathic fragilitas ossium, and osteopsathyrosis, whilst Poiak and Durante have suggested the name 'periosteal dystrophy' to distinguish it from another congenital bone affection, chondro-dystrophy foetalis or achondroplasia. At first it was believed to be incompatible with life, and that the subject of it was still-born or died within a few minutes of its birth. Then it became evident that some infants survived for varying lengths of time, whilst others, who had shown some signs of the intra-uterine affection at birth, gradually developed a tolerably healthy childhood, with a liability to fractures which slowly diminished. Thus a link was established with those cases in which the child was born apparently healthy, and an abnormal predisposition to fractures discovered only when it began to get about. Now the belief grows that these different sets of cases have a similar pathology.

THE CLINICAL ASPECT

A comprehensive picture of the disease may be formed from a few typical cases illustrating its four clinical varieties. These occur (1) *In the foetus*, (2) *In the infant*, (3) *In the child or adolescent*, (4) *In middle or late life*.

1 THE FETAL FORM

Most cases are still-born or survive only for a very short time. They usually show large numbers of fractures of the ribs and other long bones, and the lower extremities, more particularly are apt to be deformed and shortened in consequence. Some of these fractures are united.

The ossification of the skull is usually very incomplete. In extreme cases the cranial vault is little more than a membranous bag with a few small, thin, isolated plates of bone corresponding to the normal ossification centres, whilst the base is likely to be shorter than usual antero-posteriorly thus favouring a retinoid appearance of the face. In others scattered osseous plates and patches help to some extent to fill in the spaces which separate the immature flat bones of the vault. These bone islands are the forerunners of the numerous

Wormian bones which are such a conspicuous feature of the completely ossified skull of osteogenesis imperfecta. In the light of this inadequate protective covering of the brain, it is easy to understand what must be the effect of the powerful uterine contractions during labour. No wonder such cases are still-born. As a good example of this group, Dr Herbert R. Spencer's case may be cited.

Case 1 (Figs 380, 381)—The specimen is in University College Hospital Museum (No 632, Bone 61A), and is described in the catalogue as follows—



FIG. 380—*Case 1* (Dr H. R. Spencer's). The curious appearance of the skull is due probably to the interior of the membranous envelope being filled with wool. The thin calcareous plates are well shown. (Univ. Coll. Hosp. X-ray Department.)

"The skeleton of a rickety fœtus. The ossification of all the flat bones of the cranium is defective, irregular plates of very thin bone being widely separated by intervals which are in parts entirely membranous, and in others are undergoing ossification in irregular striæ. The bone in many parts is so thin as to give the finger a sensation like the crackling of parchment, the thinness being such that the shape of the skull could only be maintained by filling the cavity with wool. The lower jaw is fractured on each side in front of the masseter. The vertebral column presents a normal appearance. The wall of the thorax presents on each side a vertical groove outside the junction of the ribs with the cartilages. The ribs are sharply bent at their angles, especially on the right side, and there are several swellings of the bones in this situation which appear to indicate fractures. The clavicles and scapulae are not preserved. In the right upper extremity the humerus is curved outwards as the result of a healed fracture in the middle of the shaft. There is a recent fracture close to the lower extremity. The upper extremity of the shaft is considerably thickened. The radius and ulna present an enlargement in

the middle of their shafts following the repair of a fracture, each bone has also been recently fractured in the upper and lower part of its shaft, and the lower end of the shaft of each is thickened. In the left upper extremity the humerus is curved outwards even more markedly than the right, and presents two ununited fractures below its middle. The ulna is fractured about its middle, and the radius at a lower level. The 5th metacarpal bone is fractured at its lower end.

"The pelvis is flattened from before back, and its cavity is contracted. The inlet of the true pelvis has the shape of a triangle with the corners rounded. The left ilium is fractured transversely a little below the crest.

"In the right lower extremity the femur is bent outwards and the leg bones prominently forwards, so that the thigh and leg bones display a semicircular

outline The femur presents two repaired fractures, one at the other above, the middle, and an ununited fracture midway between the middle of the shaft and the lower epiphysis The leg bones are the seat of unrepaired fractures in the middle of their length, and in the fibula also at its upper extremity The foot bones are normal The general appearance of the bones of the left lower extremity is similar to that of the right The femur is fractured in the middle of its length, and the leg bones in two places at and below their middle In both limbs the ends of the long bones are considerably enlarged, and, as in the upper limbs, the growth in the length of the long bones is deficient

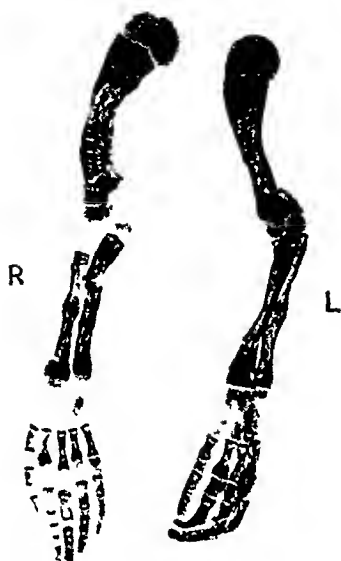


FIG 381—Case 1 Both upper extremities showing sharp epiphyseal lines multiple fractures, united and ununited, and rarefaction of cancellous tissue except where callus has formed The shortness of the diaphyses is very evident



FIG 382—Case 1 Section of upper end of femur ($\times 3$) No artificial decalcification It shows the same characters as the photomicrographs of (a c) but atrophy of the trabeculae is not so marked FIG 383 is taken from the point A (I am indebted to Dr C H Rodman for all the photomicrographs)



FIG 383—Case 1 Highly magnified ($\times 175$) portion of section in FIG 382 Cartilage cells are seen originating from the periosteum and passing between the trabeculae which are developing by metaplasia The periosteum is in the right hand lower corner

diaphyses and together with the microscopical findings (Figs 382 383), completely dispose of any question of rickets

2 THE INFANTILE VARIETY

This is the continuation of the foetal disease in those cases which survive then birth and drag out a precarious existence for a few months or a year or two. It represents a less severe form of the disease than that present in the purely foetal group. These cases at birth show marked signs of the defective intra-uterine ossification. Their fragile limbs continue to break almost with a touch, and, though the development of the cranial vault is far in advance of the membranous bag type, it is still very imperfect. Such cases may be seen occasionally in children's hospitals.*

Case 2—Dr F. J. Poynton¹ describes one that had been in hospital for two years and adds that he knew of no cases recorded in the literature in which more precise treatment had been undertaken. Yet the final condition was deplorable. All the long bones were at one time or another broken, and eventually, when the boy was lifted with the hands put round the chest, his ribs could be felt to snap.

Case 3—Another case, whose histology is illustrated by several photomicrographs (Figs 389-94, 397-9) is that of a female child who died when 20 months old. She was born with one leg broken and the other limbs bent. When 9 months old she was an in-patient at Great Ormond Street Hospital under Mr. Tyrrell Gray.

The notes state: The head was markedly flattened from before back, the ribs were slender, and the upper and lower limbs were much deformed from partial fractures. The heart, lungs, and abdomen presented no signs of disease, and the tongue was the seat of superficial glossitis. The X rays showed a marked absence of compact tissue in the different bones. For ten months before death she had been subject to fits, which continued till she died the day after her readmission to the hospital.

All the long bones of the skeleton (R.C.S. Museum, A715), "including the metacarpals and metatarsals, exhibit different degrees of imperfect formation, being abnormally slender and bent. The humeri, femora, and bones of the leg are, moreover, the seat of fractures, which in the case of the femora are multiple and fairly symmetrical. The various segments of the pelvic bones are unnaturally thin and hypoplastic, as are also the scapulae. In the shafts and bodies of the scapulae there is

* Cases of foetal and infantile osteogenesis imperfecta have frequently, in the past, been called 'foetal rickets'. There is no sufficient reason why it should not be possible for rickets to occur in the foetus. There is, however, some scepticism about it. Dr Poynton in his lecture refers to a specimen shown by Dr Dawe at the Pathological Society. The specimen was a card specimen, and no account of it is to be found in the *Transactions*, but the microscope sections exhibited were considered to show the characteristic rickets changes, and were taken from a still born child whose "ribs showed typical bending at the costochondral junctions, and the bones of the limbs similar disturbance of growth at the ends of the diaphyses" (Private communications from Dr Dawe and Professor Shattock).

A specimen in St. Thomas's Hospital Museum (No. 364A) illustrates the difficulty of making a certain diagnosis when an infant born with evident signs of some congenital bone affection survives long enough for rickets of a post-natal origin to supervene. The catalogue description is as follows: The left lower limb of an infant showing characteristic marks of rickets. In addition to the epiphyseal and other changes in the long bones, the hip bone is considerably increased in thickness. The disease was congenital. The skeleton in general was affected—the various long bones are shown in the specimen, whilst the flat bones were abnormally thickened. The child was one of twins, and was born with deformities of the limbs. The long bones during life could be bent like india-rubber. Death occurred when the child was 16 months of age from marasmus and broncho-pneumonia. The other twin, a boy, was, like the girl, very backward and unable to walk. He exhibited the same flexibility and curvature of the bones but to a less degree. Both children had been brought up on cow's milk and Robinson's food. The parents were healthy and the mother knew of nothing unhealthful in her diet during pregnancy.

An angular deformity in the femur of the specimen is obviously the result of a healed fracture.

an actual circular deficiency at the spot in which each is naturally thinnest. The ill-developed condition of the ribs has led to incomplete fractures in several situations, as evidenced by local thickenings. The bones of the face participate in the same hypoplasia. The skull is hydrocephalic."

In the calvarium (Aa 715), "the bones are extremely thin, especially the two parietals, which are translucent over the summits of the convolutions. The anterior fontanelle is widely open. In consistence the osseous tissue is quite as firm as normal."



FIG 384.—Case 4 (Mr Tyrrell Gray's) Diagram of the right lower extremity at the age of 3 years. The architecture of the bones has not been brought out owing to the tube used being soft.



FIG 385.—The same extremity at the age of 8 years. Here a 'hard' tube has brought out the bone architecture at the expense of the soft parts. Note the thin cortex, the rarefied cancellous tissue, the straight epiphyseal lines, and the evidence of old fractures.

The brain (38351, R C S Museum) has a remarkable circular outline when viewed from above. Its large size and slightly broadened convolutions suggested a condition of hydrocephalus, but on investigation the ventricles were found quite normal.

Of the internal glands the thyroid, the suprarenal, the pituitary, the ovary and the liver were examined. The thyroid only was abnormal. The cells did not line the alveoli but occupied the interior generally in a mass. In some of these masses there was a suggestion of a collapsed cavity. In others the cells were scattered generally throughout the alveolus in the colloid substance.

Through the kindness of Mr Tynnell Gray, and with the help of Mr George A Mason, I am able to refer to another case of very considerable interest —

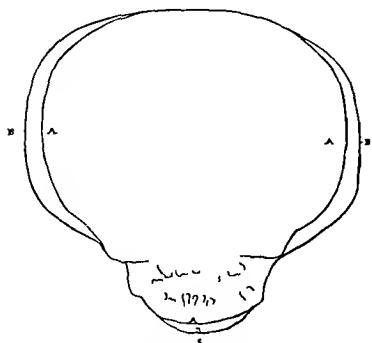


FIG 386—Case 4 Outlines of the cranium at age of 3 (A) and 8 years (B) superimposed

remarkably. Whilst the bitemporal diameter was greatly increased, the anteroposterior diameter seemed shorter than normal owing to the flattening of the back of the head. A face, small for the child's age, appeared overweighted with a bulging and greatly expanded cranium, which, however, was completely ossified. The horizontal circumference was $22\frac{1}{2}$ in., that of a normal adult skull being 21 in. Skiagrams taken when the child was 3 years old were able to be compared with those taken when it was 8. Superimposed outline tracings of the front views of the head show the increase in size during the five years to be due to lateral expansion of the vault (Fig 386).

The recent skiagrams of the limbs demonstrate well the very delicate architecture of the osseous tissue and the thinness, or in parts the absence, of cortex. The child was very intelligent, looking as it sat up in bed not unlike a child 2 years old, but giving the impression of a mentality much in advance of that age. It had never had any fits or nerve symptoms, and after the investigation of the brain in Case 3 there can be no doubt that the shape of the cranium was not dependent on hydrocephalus.

But hydrocephalus may undoubtedly be an associated condition. An example of it is seen in the skeleton of a boy, age 12 (from Professor Himley's Museum) (Fig 387), in whom the left humerus and ulna, the right radius, and both femora and the left tibia appear to have been at distant periods fractured and repaired with various degrees of distortion. The skull is of globular form and nearly symmetrical. It measures in its transverse circumference 31 in., from one auditory meatus to the other over the vertex 27 in., and from the nasal spine to the foramen magnum 26 in. (RCS Museum No 3879)²

Case 4 (Figs 384, 385)—A P., a boy, age 8 years, was first brought to the Children's Hospital, Great Ormond Street, when 3 weeks old, and frequently attended afterwards for various fractures. He measured, when laid at full length, $27\frac{1}{2}$ in., and the height of a normal boy of the same age is 47.05 in. (British Association Anthropometric Committee Report, Table 161). A proportion of this deficiency in height was explained by the curving of the spine and by the bending and deformity of the lower limbs, which was very similar to that seen in Case 1 (Fig 380), but a considerable part of it was clearly a consequence of diminished growth. The skull, like that of Case 3 was hydrocephalic in appearance. The forehead was very prominent and broad, and the temporal regions protruded



FIG 387—(No 3879 RCS Museum) Skeleton of a boy age 12 years showing osteogenesis imperfecta and hydrocephalus

5 THE DISEASE IN CHILDHOOD AND ADOLESCENCE

(Osteogenesis Imperfecta Tarda) — *See Plate, p. 714, Fig. 10*

The third category is very different from the other two, and the cases which belong to it have commonly been described under the heading of 'idiopathic fragilitas ossium'.

In the bulk of them the infant is apparently healthy at birth, and has a perfectly normal childhood except for the fact that fractures of the long bones occur at more or less frequent intervals from very slight cause. There is often some evidence of defective cranial ossification in the presence of 'soft' places on the skull but in many beyond a late closure of the anterior fontanelle signs of cranial abnormality may be almost absent on clinical examination. There are wide variations in the number of fractures in different cases. In many it is under 10, not infrequently between 10 and 50, and in a few cases it may reach well over 100.

In less aggravated conditions the liability to fracture seems gradually to wear itself out as maturity is reached. Looser pointed out that these cases of multiple fractures presented the same pathological peculiarities as the fetal and infantile cases of osteogenesis imperfecta, and suggested for them the designation of 'osteogenesis imperfecta tarda'.

A very strong familial tendency is often present in the post-natal disease. Sometimes two or three children in a family will suffer, occasionally a whole family, and more rarely several generations will show the trait. These hereditary instances sometimes present a very interesting grey-blue coloration of the sclerotic, a complication which will be considered later. The intensity of the disease may vary considerably, as the following instances show.

The first case represents a transition between the infantile and the adolescent types —

Case 5 — Fowler³ has described the case of a boy who began with a fracture on the fourth day after birth, and had seven up to the age of 3, when he was lost sight of. In addition to patent cranial sutures, the occiput was almost entirely undeveloped. The sutures were in process of closure at the fourteenth week, but he was a year old before the back of the skull was properly ossified. He was small for his age at 3.

Axmann's case⁴ is an example of the ordinary adolescent form —

Case 6 — This case is mentioned by Crozier Griffiths in these terms. "The writer gives his own family history. He and two brothers were of rather delicate build. He had a fracture of the leg in his third year, one brother had 9 fractures from the age of two to that of nineteen years, 4 of them occurring before six years of age. The other brother had 9 fractures from the age of two to that of nineteen years, 4 of them before he was nine years old. These 14 fractures (sic) occurred without the action of any noteworthy force. All healed in four or five weeks. The fragility decreased with growth and disappeared at maturity."

O Schmidt's fourth case is an instance of an aggravated form of this variety. It is of more than ordinary interest, because it formed the text for Looser's article on osteogenesis imperfecta tarda, in which a very full histological report on the different bones is given.⁶

Case 7 — "A youth, 17 years old, was descended from healthy parents. Nine brothers and sisters died at an early age in convulsions. A sister aged 14 was healthy, and a brother aged 6 years suffered from fragility of the bones."

"The labour was normal, and at birth the boy was normal and strong. He developed well in the first month, but later his health suffered owing to convulsions and much diarrhoea. He learnt to walk at the normal age, and the first fracture occurred when he was 1½ years old. Very numerous fractures followed at longer or shorter intervals, most from quite insignificant causes. Up to his 17th year he had 43 fractures in all, 40 of the legs, 2 of the upper arm, and 1 of the right clavicle. He had been in hospital with fractures of the scapulæ, upper part of the thighs, lower jaw (from chewing), forearms, upper arms, and probably of the bodies and processes of the vertebræ, besides many infractions. In the case of slight fractures they soon united. Fractures were observed to consolidate in very short periods. The great deformity due to union with much displacement made walking impossible from the 12th year. When admitted to a private home his internal organs were normal. He had kypho-scoliosis, his upper extremities were not much changed, but the lower ones were bent into corkscrew shape. Both legs being useless were amputated in the lower third of the thigh. Subsequently, during a year of hygienic and dietary treatment, the bone fragility improved considerably."



FIG 388.—Case 8. Skeleton of Ormerod's case presented to the R.C.S. Museum by the staff of the Sussex County Hospital.

4 THE DISEASE IN MIDDLE LIFE OR OLD AGE

Osteogenesis imperfecta in an active state is of rare occurrence in later life. In Dr E. L. Ormerod's remarkable case there was a relapse following a satisfactory recovery from a slightly pronounced intra-uterine form of the malady. In Hektoen's case there is no history, but the presumption is that the disease had reached a quiescent state.

*Case 8 (Fig 388).—*The skeleton in the R.C.S. Museum was given by the staff of the Sussex County Hospital, and the case was recorded by Ormerod in 1859.—

The patient, who lived to the age of 68, was the last of a family of six children, and the only one to reach middle life. His father was of dissolute habits and good physique, and died of diabetes at 55; his mother lived to 93,

and some miscarriages, and some other children who died within a few days of their birth.

He was born with his arms broken. Otherwise he was a fine child, and, though rickety improved as time wore on, until he was 30 years of age, when, in spite of his deformities and an accident four years before in which both his thighs were injured, he was 5 feet 3 or 4 inches in height, and had full use of his arms and legs.

He could walk several miles and do a good day's work as a shoemaker without any inconvenience. He was in his prime and at this age he married.

At the age of 30 he seemed to have lost all his bodily strength and his bones were so brittle that they would break at the slightest blow. His marrow, and other pecuniary losses which had reduced him to poverty, may have had something to do with the change that came over him in these ten years. At one and the same time he had no fewer than seven fractures of different bones. These were attended by little pain and swelling or constitutional suffering, and united even more readily than healthy bones. It does not appear that he suffered from any pain in the bones preceding the fractures. His wife got used to his bones breaking, and as he lay in bed for the last four years of his life a fracture might often have passed unnoticed in the family circle. It was subsequent to the age of 30 when he married and poverty overtook him that the chief changes in his skeleton, both in the gradual bending and the sudden fractures, occurred. He died worn out by the constant pain of his distortions and some ulcers on his legs, and after death when laid at full length on his back he measured 39 in.

He was the only one of his brothers and sisters to be affected in the way, but a son and a daughter suffered from frequent fractures and attended the hospital for them. Two other children died soon after their birth, but were healthy-looking.

Case 9—Hickson⁶ gives an interesting account of the findings in the case of a small, short-limbed dwarf, age 15. The skeleton whilst showing some of the features of osteogenesis imperfecta, viz., the curving of the bones, old fractures of many ribs and the left humerus, evident dehiscence of periosteal and myelogenous ossification, and a very remarkable skull presented also certain appearances suggestive of achondroplasia in the relative shortness of the limbs and the swollen condition of the articular ends (achondroplasia hyperplastica of Kaufmann).

The feature that has led me to mention this somewhat monstrous case is the condition of the skull, which is characteristic of osteogenesis imperfecta. It is remarkable for the large number of Wormian bones in its composition, viz., 172. They were most numerous in the posterior and lateral portions of the skull superplanting the parietals, the squamous portion of the temporal bones, and the upper half of the tubular portion of the occipital. Others occurred in the vertical and orbital portions of the frontal bone. The base of the skull, which is primarily developed in cartilage, was free from them.

These cases give a very good idea of the clinical characters of osteogenesis imperfecta.

There can be no doubt that the foundation of the mischief is laid in early intra-uterine life, and that the causal defect is present in the fetus even in those cases in which the first signs of trouble do not appear until after birth. The less pronounced that defect the greater is the probability that its signs will be deferred till the individual is able to get about and is exposed to the ordinary slight traumatism of a healthy life. Recovery is not necessarily permanent, and recurrence may take place when general conditions are unsatisfactory.

It would appear from a general perusal of the literature that the subjects of this affection are smaller than normal at birth and throughout life, and that the prognosis as to longevity is not good. The numerous fractures and thickening which is often present, but the feeble osteogenic process at the epiphyseal lines has no doubt considerable influence. In some cases the skin appears redundant and is thrown into folds, which has been explained on the ground that the growth in length of the bones has not kept pace with

the growth of the skin, whilst in a certain number of cases a cleftoid type of face is recorded

The fractures are in the main subperiosteal, and arise from the most trivial causes. The earlier they appear, the greater, as a rule, is the liability to them. They unite readily, sometimes more quickly than in normal bones, and the callus is much more dense than the rest of the bone. Instances of non-union are not uncommon. The small amount of pain and inflammation they give rise to may be explained by the subperiosteal character of the fracture causing little or no laceration of the soft parts, and by the atrophic condition of the bone substance. Poynton noticed that slight febrile attacks and bony tenderness preceded fracture, but probably this means that partial fracture predisposed to the final complete solution of continuity. Deformity, which in the lower extremities is often very considerable, may be due to bending of the bones resulting from incomplete fracture of a thin brittle cortex at one portion of its circumference, and not to flexibility of a softened osseous tissue, but it is mainly caused by improperly united fractures.

The ease with which union takes place suggests that the deformity is preventable, Nathan, indeed, attributes it to the fact that owing to the frequency and painlessness of the fractures, the patient, or those who look after him, become careless and fail to give the necessary attention.

The defective ossification of the skull is particularly noticeable in the vault, i.e., in that part of the skull developed in membrane, but the base also is affected. The bone developed from cartilage in other situations is composed of atrophic and widely separated trabeculae of a very porous type, and it can readily be understood that pressure, acting upon similarly formed bone in the basi-sphenoid and basi-occipital, might exert some repressive influence upon the anteroposterior diameter of the base. But it is to the want of growth resulting from the feeble endochondral ossification that the relative shortness of this part of the base is usually attributed. It is this shortness which is responsible for the cleftoid facies met with in some of the foetal cases.

In the vault, almost every degree of deficiency may be found in different cases, from a membranous sac with occasional bony spicules here and there (Stilling's case), to cases in which the fontanelles are large and the sutures still open. If the infant survives and thrives, ossification progresses and sutures and fontanelles close (*Case 5*), but occasionally a soft place in the skull may persist for years and even throughout life. The membranous areas that intervene between the immature bones are apt to become filled in by numerous Wormian bones resulting from discrete patches of ossification. Remarkable appearances are thus produced, the vault being represented by a mosaic of larger and smaller bone plates, sometimes touching one another, and sometimes united by bridges of periosteum and dura (Hektæn's, Violk's, Schmidt's, and Harbitz's cases). The skull of *Case 8* is a good example of this excessive Wormian bone formation.

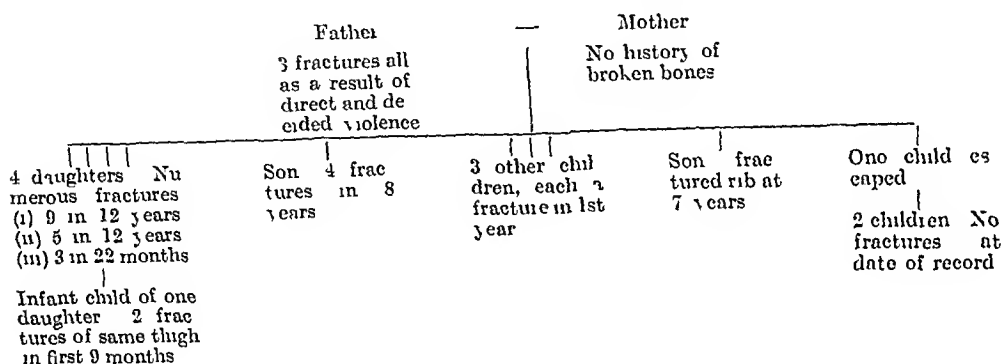
Owing to this slow and defective ossification the shape of the cranium in osteogenesis imperfecta tends to become distinctive. The bitemporal diameter is much increased, the squamous parts bulging outwards and projecting considerably above the external auditory meatuses, so that the ears are

directed downwards and outwards. This is very marked in *Case 1*, and also in *Case 3* in which the bulging involves the occipital and also to a less degree, the frontal regions.

The probable explanation of this deformity is the lack of support given the brain by its limp and pliable osteo-membranous envelope. It is apt to be looked upon as evidence of hydrocephalus, but that diagnosis should not be made without actual examination of the cerebral ventricles.

THE TENDENCY TO HEREDITARY TRANSMISSION

There is abundant evidence to show that the disease may appear in more than one member of the same family, and that even several generations may suffer. Willard⁹ records the following remarkable family history —



Other instances are mentioned by Greenish¹⁰, and still others are referred to in the next paragraph, whilst recorded cases not infrequently furnish testimony to the transmission of the idiosyncrasy.

Blue Sclerotics — A connection has recently been shown to exist between these post-natal cases of osteogenesis imperfecta and a greyish-blue colour of the sclerotic. The peculiar tint of the eyeball attracted special attention, because it was found to occur with some frequency in several members of a family and sometimes to appear in more than one generation. The discovery of a history of several fractures in one case led to the investigation of others, and it was found that multiple fractures were quite common in individuals who presented it. The blue colour is due to the partial visibility of the pigmented choroidal tunic through the sclerotic.

Such investigations as have been made would seem to show that there is no diminution in the thickness of the sclerotic compared with the normal, and no difference in its microscopical structure. It is therefore suggested that the translucency of the outer ocular coat is due to some exceptional peculiarity of the fibrous tissue of which it is composed. In support of this idea the disproportionate frequency of sprains in these people is advanced as corroborative evidence of some abnormality of the fibrous tissue in other parts of the body. The most comprehensive contribution to this subject is Bronson's¹¹. It is based upon a careful study of two families, and from his summary of the main facts connected with them we can appreciate its relation to osteogenesis imperfecta.

1 *The First Family*—In 4 generations there were 55 individuals, and 21 had grey-blue sclerotics. Of these 21, only one, a boy of 6 years, had had no fractures. The number of fractures in any individual was not excessive, and they required a certain amount of force to produce them. Sprains and dislocations were common. The majority of the adults were in good general health and able to do ordinary work. The mortality among the infants with blue sclerotics was greater than amongst those not so affected. The heads of those in this family who had blue sclerotics and bone fragility showed an abnormal prominence of the frontal and occipital bones. In two there was a history of patent fontanelle throughout life. Of 8 adults with blue sclerotics and fractures, 7 had varying degrees of deafness. The eighth died at the age of 23 without deafness.

2 *The Second Family*—This includes 3 generations and 8 individuals, 7 had blue sclerotics, and 4 of these had had fractures. Two others had a tendency to sprains. All were able to lead an ordinary life except one child, who was crippled and incurred fractures too easily to be able to run about and play. In this family the head had the characteristic shape frequently seen in osteogenesis imperfecta, viz., an increase in the bitemporal diameter, so that the ears were turned outwards and downwards. There was slight downward tilting of the eyes, and an underhung lower jaw. There was no tendency, as in the first family, to deafness, nor was there any arteriosclerosis.

In both families the stature of affected individuals was below the average, with the exception of three members of the first family.

HISTOLOGY

There is general agreement on the part of those who have had opportunities of studying the histology of the foetal and infantile forms of this disease

that (1) The stages of cartilaginous ossification are normal up to the formation of the primary areolæ, (2) The periosteal and medullary ossification is quite abnormal in character, deficient in quantity, and inferior in quality (*Fig 389*), and (3) Osteoblast edging to the trabeculæ is either absent altogether or only partially present in parts.

The various changes in the cartilage—the proliferation of the cells, then arrangement in rows or columns, the increase in their size, the formation of the zone of provisional calcification and of the primary areolæ—are stages in the process of the production of a framework on which the bone is in the first instance to be laid down.

The real process of bone-formation begins with the penetration of the areolæ by the vessels of the medulla carrying with them their covering of

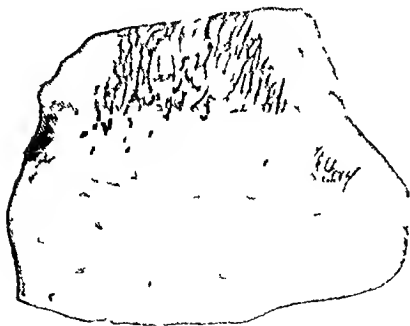


FIG 389—*Case 3*. Slightly magnified ($\times 2\frac{1}{2}$) section from the lower end of a tibia showing the very dehcate frame work of the cancellous tissue the thickened periosteum and the absence of the ordinary cortical layers.

osteoblasts, i.e., of cells of connective-tissue origin, whose function is to arrange themselves along the calcareous walls of the areolæ and surround themselves with osseous substance. It is this process that defaults. The cells present in the medullary tissue do not arrange themselves in this way and cannot therefore be recognized as osteoblasts, and the bone formed is not deposited in laminae as it is when a layer of osteoblasts fringes the walls of the areolæ or the edges of the trabeculae, but is the result of calcification of cartilage and the metaplasia into bone of the connective tissue of the marrow.

The observations that follow are derived from an examination of microscopical sections from *Cases 1, 3, and 8* examples of the foetal infantile and middle-aged forms of the disease, but for the adolescent variety I have had to fall back upon Looser's description in *Case 7*.

THE DISEASE IN THE LONG BONES

If a microscopic section including an epiphysis and part of the diaphysis is made from a long bone of either a foetal or an infantile case certain characteristic appearances can be seen with the naked eye, or, better still, on slight magnification (*Fig 390*)

- 1 The epiphysial junction is straight, regular, and sharply defined, any deviation from its straightness being so trivial as to be within the normal limits
- 2 The zone of provisional calcification is complete and well marked
- 3 In the adjacent part of the medullary cavity the trabeculae are slender and delicate, then direction is mainly in the long axis of the bone, and they are widely separated by spaces filled with a delicate connective tissue or fibrous marrow rich in cells and devoid of fat. The trabeculae do not form a continuous network. Single trabeculae, or patches of anastomosing trabeculae isolated in an expanse of marrow, occupy a considerable area of the section
- 4 The periosteum is thickened, and is much thicker than the perichondrium of the epiphysis
- 5 There is no continuous layer of compact bone beneath the periosteum but its place is taken by discrete trabeculae whose direction like that of the medulla is parallel to the long axis of the bone

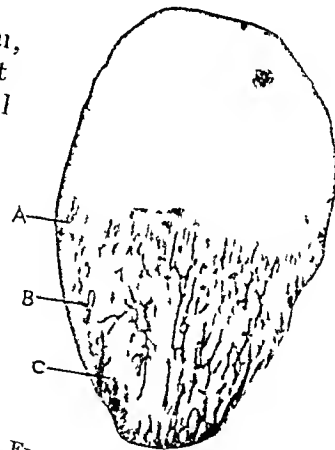


FIG 390—*Case 3* Section of a rib showing the costochondral junction which is sharply defined. Very slightly magnified ($\times 21$). The next three photomicrographs were made from positions indicated by the arrows but from a corresponding section A *Fig 391* B *Fig 392* C *Fig 393*

The microscopical appearances at different parts of the section may next be studied

- 1 **The Formation of Bone from the Cartilaginous Epiphysis**—The changes in the cartilage up to and including the zone of provisional calcification do not differ from those present in normal ossification from cartilage

The provisional zone is well formed lime salts being deposited in the strips of matrix separating the columns of cells, with great regularity. It is below this that the abnormal appearances begin (*Fig 391*). Calcareous processes form across the space between the struts, and a number of superposed cartilage-cells become enclosed in a calcareous envelope. The capsules of the cells themselves may show signs of calcification. Groups of two or three of such compartments of enlarged cells (primary areolæ), lying side by side and incorporated in calcareous material, constitute the most recently formed trabeculae. The further growth of such trabeculae, which, however, is only slight, takes

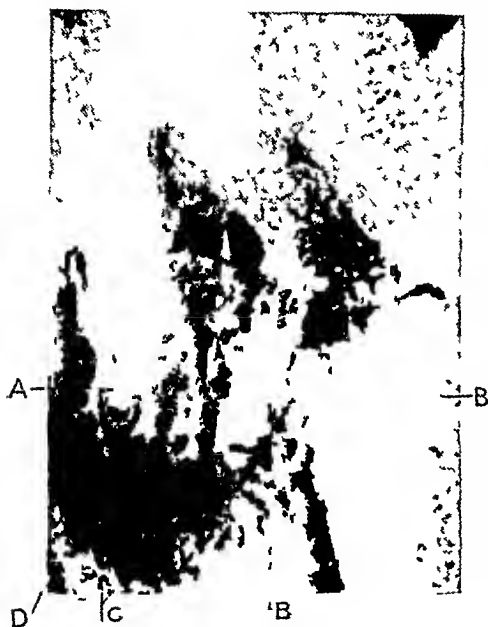


FIG 391—*Case 3* High power view ($\times 110$) of trabeculae beneath the periosteum just below the juxta epiphyseal region (rib), showing A Adjacent columns of cartilage cells from epiphysis B Advancing metaplasia of the marrow connective tissue into bone, C Giant cells D Periosteum. The periosteum is immediately on the left of the trabecula and sufficient of it is not included to enable it to be recognized (See *Fig 390, A*)

place by an extension of a granular calcareous deposit in the connective-tissue groundwork of the adjacent marrow, numerous cells being included (metaplasia). These cells are of considerable size, and the nucleus is surrounded with much clear cell substance. The spaces containing them are very numerous, large, and closely set, and with the persisting hypertrophic cartilage-cells, which can be traced far down into the medulla, form a conspicuous feature of the bone trabeculae.

THE FIRST MARKED DEPARTURE FROM THE NORMAL PROCESS OF OSSIFICATION IS THE FORMATION OF TRABECULAE BY THE CALCIFICATION OF THE CARTILAGE, AND THEIR EXTENSION BY METAPLASIA OF THE ADJOINING CONNECTIVE TISSUE OF THE MARROW.

Intimately associated with this, and without doubt the cause of it, is THE SECOND IMPORTANT ABNORMALITY, VIZ., THE COMPLETE ABSENCE OF ROWS OF OSTEOBLASTS.

2 The Formation of Bone under the Periosteum—The periosteum is seen to be considerably thickened, and its deeper layers are composed of very

elongated cells with flattened nuclei. These pass gradually into the cells of the marrow and lose then flattened elongated appearance. This portion of the periosteum has been called the cambium layer. Where bone-formation is taking place, the cellularity is markedly increased.

The trabeculae are formed by metaplasia (*Fig 392*), lime salts being slowly deposited in the connective-tissue fibrils between the cells after they have assumed a rounded form. In this way a trabecula may be forming on one side from the under surface of the periosteum, and on the other from the medulla. The cells engaged in this process are large, and may be closely packed together with very little intercellular substance. As they are

incorporated in the bone, the trabecula becomes honeycombed with cell spaces as closely set as the apertures in a piece of perforated zinc.

The character of these cells is remarkable. In Case 3 many trabeculae immediately abutting on the periosteum, and clearly originating in connection with it, present appearances very suggestive of the presence of included cartilage-cells. Here and there groups of spherical cells unmistakably cartilage, may be seen lying against a trabecula on its periosteal side and in process of inclusion (Fig 393).



FIG 392—Case 3 High power view ($\times 110$) from rib (See Fig 390, B) Trabeculae forming in the deep layers of the periosteum by metaplasia. A Periosteum. B Cartilage cells. [All the photomicrographs are from untouched plates.]

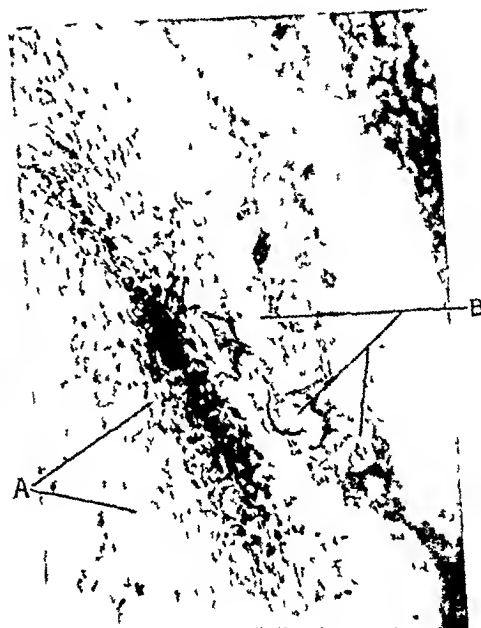


FIG 393—Case 3 High power view ($\times 110$) from rib (See Fig 390, C) Cartilage cells lying against a trabecula on its periosteal surface, and being included in it. The cellularity of the periosteum at this point is very marked. A Periosteum, B Cartilage cells.

In Case 1 the section shows a very clear transition from the deeper cells of the periosteum to cartilage-cells closely fitted together.

In both cases (1 and 3) the cartilage cells arising from the periosteum are well seen at a considerable distance from the epiphyseal line. There is no possibility of any doubt as to their periosteal origin.

THE THIRD IMPORTANT DEPARTURE FROM THE NORMAL IS THE PRODUCTION OF CARTILAGE-CELLS BY THE PERIOSTEUM INSTEAD OF OSTEOBLASTS (Fig 394). It is the outstanding feature of the subperiosteal ossification. The cells appear to retain their cartilaginous appearance after incorporation in the trabeculae and become surrounded with lime salts, assuming apparently some part of the osteoblastic function, but the osseous tissue resulting differs in appearance and in amount from that produced by the true osteoblast.

Klotz¹² who has described with great clearness the histological appearances in the case of a full-time child who lived only five minutes, drew

particular attention to this development of cartilage cells from the periosteum, and suggested the following interesting explanation

In its earliest form the foetal bone is composed of cartilage. Ossification begins in the centre of its shaft, and gradually advances until only the ends of the bone retain their cartilaginous character. A membrane—the perichondrium—surrounds the cartilaginous shaft, and cartilage-cells grow on its inner surface. As the shaft commences to ossify, the membrane overlying the bony portion thickens and increases in vascularity, and the cells in its deep layer proliferate and form osteoblasts. It then becomes periosteum. In the cases now being considered, Klotz points out that the periosteum retains

its early foetal function of producing cartilage-cells, but he seems to hesitate to look upon them as cartilage-cells pure and simple, and would place them midway between cartilage-cells and osteoblasts.

Returning, after this digression, to the histology of the cases specially examined, it may be noted that the special feature in *Case 3* was the extremely atrophic condition of the trabeculae. In *Case 1* the subperiosteal cartilage-cells were very numerous, and passed between the trabeculae in a compact arrangement into the medulla (see *Fig 383*). They were identical in appearance with the cartilage-cells of the epiphysis just above the provisional calcified zone in the same section (see *Fig 382*). The marrow, where it was less cellular, showed a delicate fibrous structure, and the fibres had a tendency to sweep round the ends of the trabeculae and the sides of concavities. In neither case was fat present in the marrow in any of the sections. Finally, the trabeculae, whether of epiphysial or



FIG 394—*Case 3*. A low power view ($\times 30$), having the part shown in *Fig 393* in its centre. It shows the porous character of the trabeculae formed in osteogenesis imperfecta and an early deposit of lime outlining rounded cells across a medullary space. The relation of the periosteum to the trabecula is clear.

periosteal origin, were calcified throughout, osteoclasts were present in fair numbers, but resorption was not thought to be abnormally active.

The adolescent form of the disease (fragilitas ossium) presents some suggestive differences from the above. Its salient features emerge from a study of Looser's careful examination of *Case 7*.

a The trabeculae of the spongy tissue of the medulla were very delicate and small. The cortex of the shaft was excessively thin and porous, and appeared on section, not as a continuous layer, but as a great number of smaller or larger irregularly-shaped trabeculae.

The marrow was largely fatty—fat-cells even extending into the deep surface of the periosteum between the gaps in the cortical trabeculae. Its vascularity was slight.

b A more normal type of ossification was found at the epiphysial disc. Processes of marrow, carrying cells, penetrated the cartilage, and rows of osteoblasts formed upon the struts of the calcified zone. This, however, was only partial. The trabeculae generally carried a regular edging of osteoblasts. It was evident, however, that the osteoblasts did not function in a normal manner. Only a very small amount of osseous substance was deposited around them, so that the trabeculae contained numerous cell spaces. They were also striped and lined, strongly suggesting a lamellar system, but the bone substance had a more or less crumbling appearance. Evidently the evolution of the osteoblast had made very definite progress, but that cell had not yet reached the stage of the finished article.

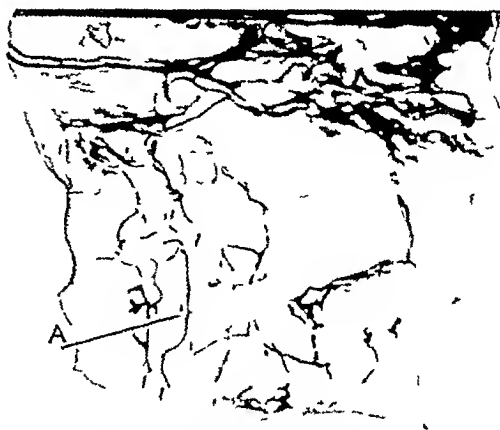


FIG 395—Case 8. Man, age 68. Section from the head of the femur ($\times 41$). The atrophic trabeculae are maintained in position by the celluloidin. A. Calcareous debris.

The middle-aged or senile form —

Still other appearances may be seen in later life. A section was taken from the head of one femur in Case 8. In order to maintain the parts *in situ* it was necessary to preserve the celluloidin in which the specimen was mounted for cutting.



FIG 396—Case 8. A broad trabecula from a corresponding section to that shown in Fig 395 ($\times 30$), showing rarefactive absorption. A. Minute pitted appearance, due to cell spaces.

It shows to the naked eye a few thin red lines of bone (eosin stained) traversing the section, and at the surface forming a very delicate widely-spaced network. Under the microscope (Fig 395) these lines show as slender elongated bone trabeculae, having a fibrous laminated structure in some parts, and a certain resemblance to normal laminated bone in others. Where the section is thin, a very finely pitted appearance is seen, due to the closely aggregated cell spaces. The larger trabeculae show a curious con-

dition. An irregular excavation of the surface is mapped out in the form of channels, hollows, holes, and shallow spaces. The excavations are sharply bordered by the more deeply eosin-stained thicker parts, but occasionally the edge is shelving. The whole trabecula presents the finely pitted appearance

just described, as well as larger spaces. Evidently the bone substance is disappearing rapidly, and not by the ordinary process of giant-cell absorption.

The spaces separating these attenuated trabeculae show a tracery of faintly delineated circles suggestive of fat-cells, and scattered in parts of this tissue are groups of granules and spherules of lime, staining deeply with hæmatoxylin. These appearances seem to indicate that, during the period of healthy life, bone-formation assumed an approximately normal character (compare the adolescent form), but when relapse occurred, not only did the waste fail to be made good, but with age and increasing decrepitude, ineffective absorption became very pronounced (*Fig 396*). That process would be facilitated by the abnormal architectural and crumbling character of the osseous substance peculiar to this affection. Finally, the disappearing bone and marrow reached a condition of adipocoele (first of fat, which later became saponified), in which traces of the osseous debris can still be detected, although the section is a decalcified one.

THE DISEASE IN THE SKULL

A section cut from a part of the calvarium of *Case 3* (*Fig 397*), where it was very thin, showed bone of two very different characters. The prevailing formation was granular and not laminated, and numerous cells of peculiar appearance were evenly distributed through it. Larger than ordinary bone-

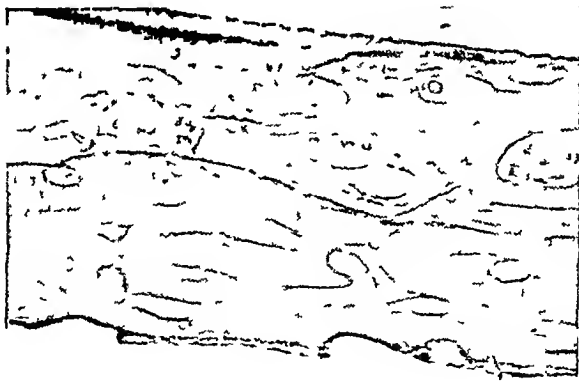


FIG 397.—*Case 3*. Section through a thin portion of the calvarium ($\times 50$) showing two kinds of osseous tissue. A. A granular type of bone containing many cells and not laminated. and B. A laminated form in immediate relation with the lacunae.

cells, of a rounded or angular shape, and having a large deeply staining nucleus in the centre of a clear zone, they would have been regarded as cartilage-cells in any but a membrane bone.

A number of lacunar spaces were also present in this section. They were filled with a myxomatous marrow, and here and there was a very partial attempt at an edging of osteoblasts, rarely amounting to more than a few cells. But these spaces were surrounded by zones of almost normal-looking laminated bone, which by reason of their different architecture, their fainter

staining, and then more or less circular shape, contrasted strongly with the granular many-celled bone in which they were placed. Some, when the lacunar space was almost obliterated, were as conspicuous as knots in a plank. Where the skull was thicker (*Fig 398*), much of this granular bone was replaced by the laminated form, so that the latter predominated. Large diploic spaces had formed, which were filled with normal marrow, and in places then boundaries were fringed with osteoblasts. Both tables were developing. Clearly in certain parts of the calvarium there were indications of a tendency to a recovery of function on the part of the bone-forming cells

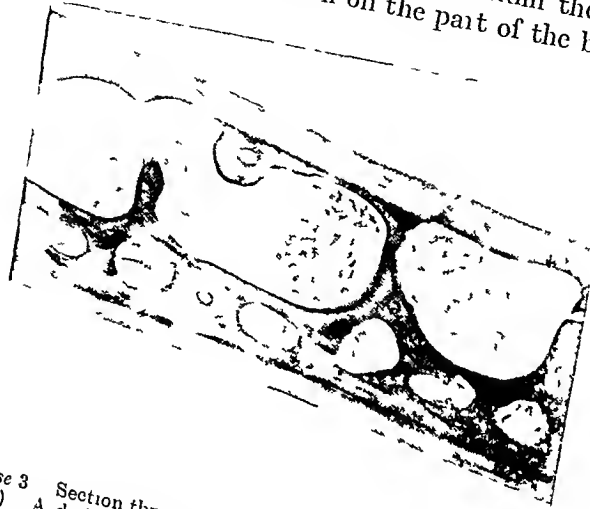


Fig 398—Case 3 Section through a part of the vault where the bone was thicker than in *Fig 397* ($\times 30$). A diploe is forming and both tables are developing. The character of the bone is more normal. It shows lamination. Hardly a trace of the granular non-laminated bone seen in *Fig 397* can be detected.

It would appear, moreover, that recovery had been complete in the skull of *Case 8* (age 68 years), for a section showed normal laminated bone, and a relapse of thirty-eight years' duration had failed to impair its effects. Yet the morbid process had been active during the period of ossification, for its traces are seen in the increased bitemporal diameter and the numerous Wormian bones.

Two points of some interest arise in connection with these histological observations: (1) *The relation of the cartilage-cells to the calcareous deposit*, (2) *The nature of the bone formed*.

1 The Relation of the Cartilage-cells to the Calcareous Deposit—The formation of the provisional calcification zone has been so taken for granted as a natural phenomenon that the cause of its formation has not excited curiosity. It is conceivable that it is part of the function of a cartilage-cell in a certain stage in its life-history to surround itself with lime, but this may really be an example of the accepted teaching that lime salts are apt to be deposited in a tissue that is dead or almost dead. In favour of this latter view is the fact that the cartilage-cells swell up just above the zone and speedily disappear below it when osteoblasts are

carried amongst them by the marrow processes. In osteogenesis imperfecta where no osteoblasts are present to be carried amongst them, the calcareous deposit extends, and groups of swollen cartilage-cells become entombed in a calcareous mass, whilst even the capsules of the cells may show signs of calcification. The cartilage-cells that develop from the periosteum are not a normal production, but they also become surrounded with lime when they have arrived at maturity, and as many of the cell spaces in the trabeculae are empty, it is probable that their life is a short one. Hyaline cartilage is, in the main, a transitory tissue.

The cartilage-cell has a much lower vitality than the osteoblast. The latter becomes a bone-cell, and as such helps to maintain the bone's nutrition, and probably, when liberated, as in fracture or in tabetic joints, exercises a considerable influence in the development of fresh osteoblasts.

2 The Nature of the Bone Formed—The distinctive histological features of the bone-formation have been considered. The fragile character of the bones depends upon (a) The absence of cortex, or its fragmentary nature and exceeding thinness when present, (b) The sparse delicate and widely-separated trabeculae, honeycombed by closely-set cell spaces, and (c) The nature of the osseous substance.

The latter is formed by the deposit of calcareous granules in the very limited connective-tissue stroma separating the cells. Consequently the hard material between the cell spaces is much less in amount than in laminated bone formed by osteoblasts, whilst in appearance it is less densely compacted. Such bone would offer but little resistance to resorption, especially if the cells it contained were either dead or of very impaired vitality, and there can be no doubt that resorption of the feebly constituted bone is not a negligible factor in the production of the atrophic conditions of the disease. There is evidence to show that it may occur without the intervention of giant cells (*Case 8*) in the senile form, and even in the earlier varieties of the disease it is not improbable that resorption by osteoclasts, and disintegration without them, go on together. It would be difficult otherwise to account for the extreme tenacity of the trabeculae in spite of the osseous metaplasia of the delicate marrow.

PATHOGENESIS

The absence of osteoblasts, and the formation of cartilage cells from the periosteum, instead of osteoblasts, are the two most suggestive histological features in osteogenesis imperfecta. How are they to be explained?

If the pathogenesis of blue sclerotics is to be linked up with that of osteogenesis imperfecta, it is necessary to go back to the connective-tissue cell, or even to the mesoblast cell which precedes it.

Fibrous tissue, cartilage-cells, and osteoblasts are specialized forms of connective-tissue cells, and each is found in places where it is specially adapted for the work that has to be done. We do not know what determines the development of fibrous tissue, of the cartilage-cell, or of the osteoblast, from the connective-tissue cell under normal circumstances, but environment is probably of considerable importance, and the evolutionary influence of function is not to be overlooked.

Now, in the disease under consideration something goes wrong in the evolution of the osteoblast, and a cell of poor vitality and one functionally less well adapted for good bone building, i.e., the cartilage cell, is produced in its stead (see Fig 383). This fundamental error of evolution is responsible for the affection known as osteogenesis imperfecta.

In the absence of the requisite knowledge, an intelligible theory, even if there is but little to justify it, may at least help to a better appreciation of the disease which, it must be admitted, is not easy to understand. We may conceive the affection to have its origin either (1) *In a quality implanted in the connective-tissue cell itself at an earlier period of its development*, and destined to influence its future evolution unfavourably, or (2) *In some influence acting upon the cell from outside*, and not of necessity directly.

It is possible that both causes may play a part.

1 An Intrinsic Cause—In a previous lecture¹³ I have discussed the frequency with which one tissue or organ of the body is apt to degenerate earlier than the rest, or proves to be less able to resist harmful influences, and how this delicacy of tissue is not infrequently manifested in more than one member of a family or handed on to the offspring. If we recognize, as we must, the possibility of the existence of such defective vitality in some particular tissue or organ, it would seem easy to concede it to the cells of which they are composed or from which they are developed.

Let us then suppose that a certain weakness, defect, or want of stamina is engrafted upon certain mesoblast cells, or upon the connective-tissue cells themselves a little later in the growth of the embryo. They may have sufficient vital force to carry them through certain stages of their evolution, but not enough to enable them to form their more highly specialized products in full perfection. Thus in one direction the fibrous tissue formed may be of poor quality (blue sclerotics, liability to sprains), in another, when called upon to produce osteoblasts they are unable to do it, but put forward the cartilage-cell as the best they can do in that line. Osteogenesis imperfecta is the result.

There can be little doubt that the evolution of the cell is largely dependent upon or influenced by its environment. What the environment does, or how it does it is at present quite concealed from us. Extrinsic influences no doubt come into play, but the cell itself must contribute something to the evolutionary process. If it lacks vitality if it fails in point of stamina the process will almost certainly be influenced unfavourably.



FIG 399—Case 3. High power view ($\times 150$) of cranial vault, showing the character of the cells included in the forming bone. The resemblance to cartilage cells is marked.

One of the most arresting of the histological phenomena was the cartilaginous appearance of the cells in the skull sections. There is no question here of the membrane, in which ossification occurs, retaining its foetal function. Cartilage-cells are not at any time formed normally in the membrane bones, and that fact raises a doubt as to whether the cells are really cartilage-cells. There is not, however, sufficient justification for the doubt. If the connective-tissue cell has not sufficient vitality to go on to the evolution of the osteoblast we might expect it to default in the membranous cranial bones as well as in the long bones. If it produces the next best thing in the latter, it might surely be allowed to do the same in the former (*Fig. 399*).

In connection with this point it is interesting to note that a tendency towards recovery appears more quickly in the skull, and advances further and is more lasting, than in the long bones.

2 An Extrinsic Cause—The other possibility is that the disease may arise in some obscure way by the failure of an external influence normally brought to bear upon the cells which are destined to develop osteoblastic functions.

The well-established connection of the anterior lobe of the pituitary, the thyroid, and the testicle with bone growth has naturally caused attention to be directed to the possible association of one or other of the internal glandular secretions with osteogenesis imperfecta. It is thought that these secretions, which no doubt are carried by the blood-stream, may exert an indirect rather than a direct effect—that they may stimulate other cells within the bone to form hormones which may in their turn act upon the bone-forming cells themselves.

There is very little to support this idea in the case of osteogenesis imperfecta. In a few cases thyroid peculiarities have been noted, but no definite alteration in any of the glands credited with the formation of internal secretions has been found except in very occasional cases. Consequently, until more is known on this somewhat vague subject we may regard the association as accidental.

On the other hand, there is an objection of some moment to the hormone theory.

In those instances in which the action of hormones has been established, it is fully-developed and often functioning cells that they stimulate to activity. Secretin may be taken as an illustration. Secretin is formed when acid stomach contents pass over the duodenal mucous membrane, and, when conveyed by the blood-stream to the pancreas, stimulates the pancreatic cells to secrete. Moreover, the influence of the internal secretions upon bone-growth so far as it is known is connected with their probable effect upon healthy, normally developed cells (acromegaly, cretinism, eunuchs). Now in osteogenesis imperfecta the fault is one of evolution—cartilage-cells are produced when osteoblasts ought to be, which is quite a different state of affairs.

The intrinsic theory as an explanation is simple and easy to understand, and there is more to be said in favour of it than for the extrinsic—at any rate at the present time.

TREATMENT OF THE CONSTITUTIONAL STATE

If the cause of the failure of the connective-tissue cell to develop into an osteoblast is due to a want of stamina on the part of the cell, the indication is clear, viz, to promote health in every possible way by such general measures as are adopted in the case of delicate and poorly developed children. The life-history of Dr Ormerod's case (*Case 8*) is valuable evidence of the good that may result from favourable conditions of life, and of the ill effects that may follow then withdrawal. The improvement produced by dietary and hygienic treatment in Looser's case (*Case 7*) is also worthy of note. But when the affection is pronounced as in many of the infantile cases, nothing is known to do good (*Case 2*, Poynton's).

It would have been impossible for me to have worked out my subject without much kind and generous help from Sir Arthur Keith, Professor Shattock, Mr Tynnell Gray, Dr G H Rodman, and Dr Donald Paterson, to name those to whom I am most indebted. To them and to several others, most of whom I have mentioned in the text, I tender my most grateful thanks.

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THE TREATMENT OF SIMPLE PAPILLOMA OF THE BLADDER BY FULGURATION

By W GIRLING BALL, LONDON

ALTHOUGH the endoscopic method of treatment of simple papillomata of the bladder by high-frequency currents was introduced by Beer, of New York, so long ago as 1910, and many subsequent writers on the subject, including Thomson-Walker in this country, have written excellent descriptions thereof, its advantages do not appear to have been appreciated sufficiently to lead to its universal adoption. The reasons for believing that trans-urethral diathermic cauterization should replace the older procedure of suprapubic removal in selected cases may be summed up briefly as follows. In experienced hands it is usually easy of application, the patient seldom requires to remain in bed for more than forty-eight hours, if at all—a point of considerable importance as compared with the weeks required for recovery from a suprapubic cystotomy and its possible complications, there is less liability to the production of cystitis and its attendant evils, the likelihood of a recurrence of the growth, or of re-formation in other parts of the bladder, is diminished, the operation can be performed under local anæsthesia applied to the urethra in cases in which a general anæsthetic is either unnecessary or undesirable, and, lastly, in those patients who have already been submitted to suprapubic excision, small recurrences can subsequently be readily kept in check.

The object of this paper is to describe the method as I have used it, and to illustrate it with the appearances seen at the time of the operation, and the changes observed as the result of such treatment.

The high-frequency machine used in the earlier cases was that supplied by Schall, which worked very satisfactorily, but it had the disadvantage of being cumbersome and non-portable. More recently the instrument supplied by the Genito-Urinary Manufacturing Co. has been used with equal effect. This machine has the advantages, amongst others, of being portable, is supplied with an excellent foot-switch which enables the operator himself to make and break the current, and of working off a constant current of various voltages.

The active electrode consists of a wire with a platinum or copper tip about eight inches long, covered with insulating material of such thickness as to render the whole calibre as large as that of a No. 6 ureteric catheter.

The indifferent electrode is a metal plate (6 in. by 8 in.), which, wrapped in a towel soaked in 10 per cent saline in order to keep even contact with the skin, is placed over the suprapubic region, this pad should be kept moist throughout the operation.

The desirability or otherwise of performing the operation under an

FULGURATION IN PAPILLOMA OF BLADDER 761

anæsthetic is a matter of some importance, it varies with the practice of different surgeons. It has been my custom to carry out the treatment under general anæsthesia, even in the case of small growths. The reason for adopting this attitude has been that under these conditions a repetition of treatments has often been avoided, some growths have been destroyed at a single sitting, which otherwise would have required a number of treatments, much larger growths have been treated by this means which might have had to submit to suprapubic removal. Repetitions of treatment are sometimes required even under a general anæsthetic, but are more frequently necessary if only local anæsthesia is used, under the latter, the sensitiveness of the urethra or the irritability of the bladder prevents the retention of the catheterizing cystoscope for the prolonged treatment required for the effective destruction of the growth, moreover, pain due to the accidental touching of the normal mucosa by the terminal is sometimes troublesome. As a general rule it may be said that a general anæsthetic is not a necessity for the treatment of small growths, or even the larger if the patient is prepared to undergo a number of treatments, but that on the whole its use is desirable.

Having introduced the catheterizing cystoscope into the bladder, which is distended with 12 oz of sterile water, an accurate survey of the growth or growths is made, especially with regard to size, number, and position, then frequent close relationship to the ureteric orifice renders this liable to damage, its position therefore must be carefully noted. The nature of the growth must be defined, due attention being paid to the history, its cystoscopic appearance, and other clinical findings. Sometimes it is difficult to distinguish between simple and malignant papillomata. If a bladder growth shows definite evidence of malignancy, in my opinion this method of treatment should not be adopted, but a partial cystectomy advised, it is impossible to estimate the degree of involvement of the bladder wall from the cystoscopic appearances and it is for this reason that the method seems to be contra-indicated. Fulguration is chiefly applicable to those growths possessing definitely benign characters. In some doubtful cases it may also be used and with beneficial effect, the results of the treatment may, however, lead one subsequently to doubt the innocence of the characters of a particular growth—a point which will be referred to later. If the treatment leads one to think that the growth possesses malignant characters, this method should not be persisted in.

The method of attacking the growth must next be decided on. As a general principle it should be laid down that the surface of the growth should be first destroyed. It is generally thought, and there is some proof of it that vesical papillomata are capable of forming implantation growths on other portions of the bladder wall. The less frequent recurrence of papillomata treated by this method, as compared with those otherwise dealt with is presumably due to the fact that the cells are destroyed prior to their spilling on the normal mucosa. The complete destruction of the smaller growths should always take place from the surface thus maintaining the advantage that only dead portions of the growth fall on to the base of the bladder.

In the case of very large pedunculated growths this is not always possible, it may then be feasible to attack the pedicle and burn it across, the growth thus detached from the bladder may subsequently be washed out through a Bigelow's evacuator if it will not come out through the cystoscope, it may be possible in some cases, when the pedicle cannot be seen owing to the overhanging villi, to burn away the front portion of the growth and then proceed as above.

In the earlier method of treatment by high-frequency currents as recorded by Beer, Judd, and Fullerton, the terminals were not embedded in the growth, but cauterization was produced by sparks shot at the growth from a distance. Diathermy, however, requires that the terminal should be embedded in the growth, the tissues being destroyed by coagulation, which leads to subsequent sloughing, ulceration, and healing. In all the cases that have come under my care this form of treatment has been adopted.

Having determined the mode of procedure, the active terminal is passed through the cystoscope and is made to approach the growth, into which it is embedded, the current is then turned on by the use of the foot switch, the current should not be allowed to pass unless the terminal is in contact with the growth, the site of the burning must be kept in view during this procedure.

DESCRIPTION OF FIG. 400

(A) Shows the papilloma before treatment was commenced. (B) A close view of the approach of the terminal to the growth. (C) The terminal is embedded in the growth. (D) Coagulation taking place with the current turned on. (E) The appearance at the completion of the operation. (F) The appearance as seen a fortnight later. The ulcer had healed a fortnight later and at the end of three years there had been no recurrence.

The tissues in close relationship to the terminal are first noticed to whiten as the result of coagulation, which spreads in all directions the longer the two are in contact. This is followed by the liberation of a number of bubbles, accompanied by a hissing sound which can be heard through the cystoscope, sparks are then observed to fly owing to the bad conduction of the tissues, which by this time have become blackened and charred. The process should be stopped by switching off the current as soon as the bubbles appear. At this stage the terminal can be withdrawn without any adhesion of the growth. When the tissues become charred, the current becomes ineffective on the deeper tissues, and the terminal sticks to the growth, this may have the advantage of allowing portions of the undestroyed growth to be torn away with it when it is withdrawn, and thus aid in its more rapid destruction, but this of itself may be disadvantageous as being productive of hæmorrhage which, although small, may be sufficient to interfere with further progress, moreover it allows some of the living cells to come in contact with the normal mucosa, which as has already been stated, should be avoided as far as possible. After withdrawal of the terminal it is embedded into a fresh portion of the growth, and the process is repeated until the whole of it has been destroyed, down to the base of the pedicle, this must now be attacked and coagulated, together with a small area of normal mucosa round its base. Experience



A



B



C



D



E



F

alone will gauge the extent to which this is required, but it is difficult to do serious damage when it is realized that the penetration of the current is probably no more than the diameter of the terminal, which in this instance is very small



A



B

FIG 401—Illustrates (A) a small growth, its pedicle, and the surrounding mucosa treated at one sitting with (B) the appearances seen at the end of the operation. The slough of the growth came away in one piece at the end of a week, leaving an ulcer which had completely healed a fortnight later. At the end of six years there had been no recurrence.

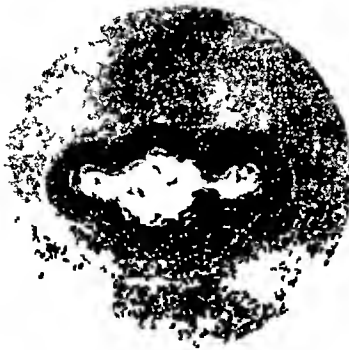


FIG 402—Illustrates the appearance seen after cauterization of three small papillomata situated in close relationship to each other. The charred remains in the centre are the destroyed pedicles. The neighbouring mucosa shows a small area of superficial coagulation. This is a typical appearance seen after destroying the smaller growths.

As with each application of the terminal a certain amount of debris is formed which falls into the surrounding fluid, it becomes necessary to empty and refill the bladder frequently, this, in addition to keeping the view of the

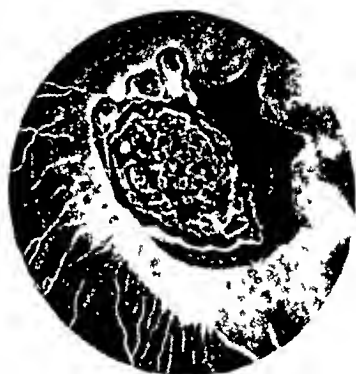
proceedings clear, has the advantage of maintaining the distending fluid at an even temperature, and of permitting the cleansing of the terminal which becomes coned with adherent growth (sometimes scraping with a knife is required). Portions of broken-off, undestroyed growth, which almost inevitably come away despite precautions to the contrary can be collected for microscopic examination if thought desirable, although the information is seldom sufficient to distinguish between innocency and malignancy.

All the above-mentioned changes are shown in *Fig 400*

Hæmorrhage seldom occurs during the operation unless, as has already been mentioned, untreated portions of growth are torn off by adhesion to the terminal, should it do so, and the bleeding vessel can be located the application of the electrode to that spot will suffice to stop it in the majority of cases. The application of hot water with the addition of adrenalin is all that is required if this method fails.



A



B

FIG 403.—Illustrates a growth (A) with the appearances (B) seen a fortnight after the fulguration. There is a white slough at the site of the pedicle base and an area of coagulated normal mucosa around it still showing. A small portion of untreated growth is seen at the top of the slough, this came away with the slough, leaving an ulcer which was completely healed when observed cystoscopically a fortnight later. This case was treated seven years ago and there has been no recurrence.

Great care should be taken in washing the bladder repeatedly at the end of the procedure in order to minimize the risk of leaving small portions of living growth behind to act as potential implantation growths. Thomson-Walker advocates the use of weak solutions of silver nitrate (1-10,000) in order to destroy any vagrant cells. During the next twenty-four hours a little bleeding may occur, it never lasts longer, more often there is none at all.

The subsequent changes observed are those associated with necrosis of tissue elsewhere, a greyish-white or yellow slough forms at the site of the pedicle base surrounded by an area of œdema which throws the neighbouring mucosa into folds or bullæ, this, again, is surrounded by an inflammatory

zone of varying width gradually fading off into the normal tissue. The slough separates at the end of ten to fourteen days, an event sometimes accompanied by slight hæmorrhage observed, as a rule, during one or two acts of micturition only, it is never severe or a cause of anxiety. The patient may be conscious of passing the slough if the pedicle was of wide dimensions. When seen a fortnight later, the resultant ulcer, dependent on the extent of the growth and the degree of destruction required, will usually be healed, and

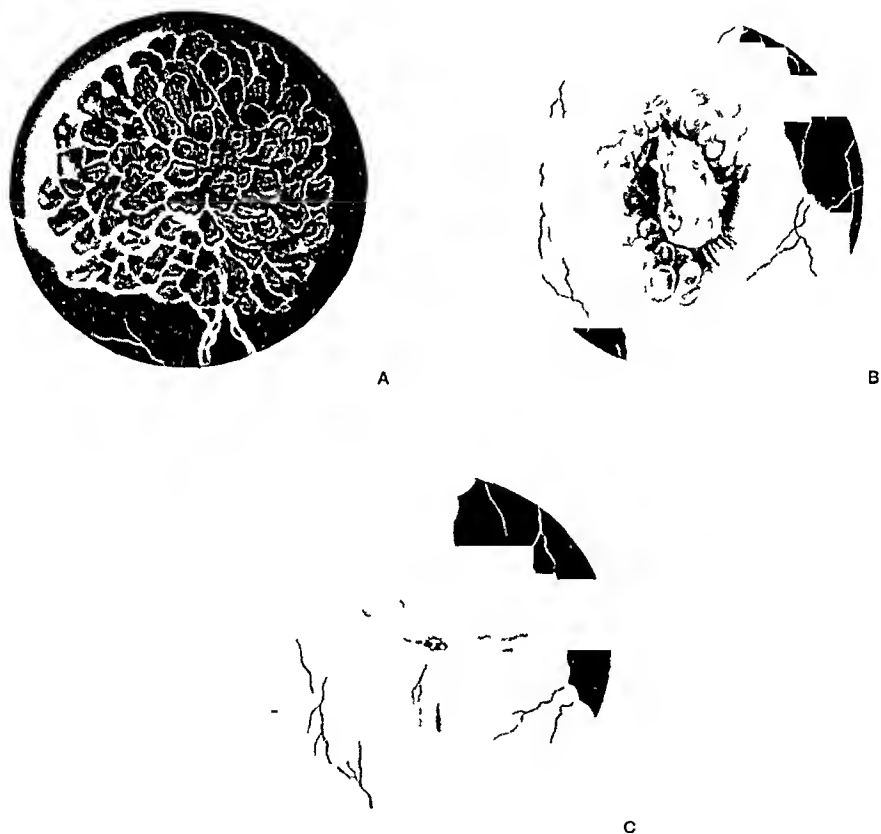


FIG. 404.—Illustrates a large papilloma (A) dealt with at one sitting. (B) shows the appearances seen a fortnight later demonstrating the characteristic œdema around the slough. (C) shows the condition of the bladder at the site of the papilloma fourteen days later. This case was treated eight years ago and there has been no recurrence.

quite frequently not even a scar can be seen. In the best-treated cases not even a depression of the surface can be found. The whole process is apparently an aseptic one, for, with the exception of the occasional presence of blood, no abnormal constituents are found in the urine, bacteria are conspicuous by their absence, unless they have been present prior to the operation, which is rare with the benign type of papilloma.

FULGURATION IN PAPILLOMA OF BLADDER 767

In the case of large growths, second or even third sittings may be required, even if treated under general anæsthesia, the usual reason for this is that the operation becomes very tiring to the surgeon after it has lasted for two hours, a factor which constitutes one of the disadvantages of the method

These secondary operations, in my experience, are not commonly required,

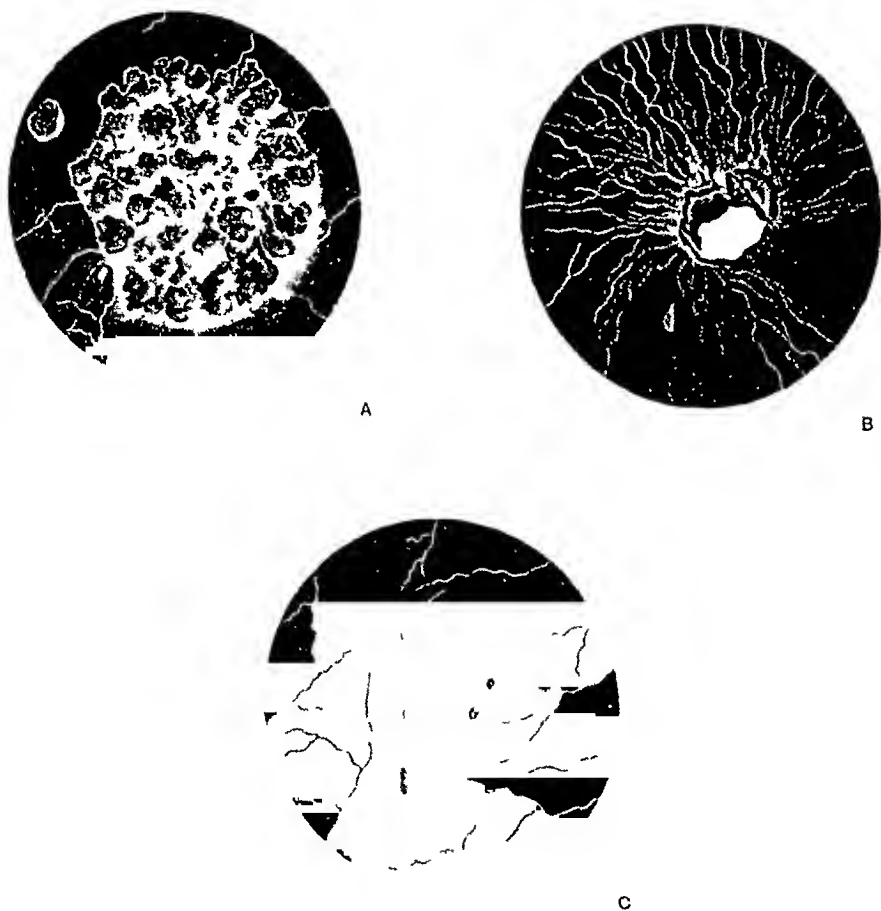


FIG 405—Illustrates (A) a large papilloma with a small one closely adjacent (B) shows the appearances seen a fortnight after the treatment, and (C) after a further fourteen days. This growth was treated seven years ago there was a small recurrence at the same site two years ago which was dealt with by the same method, without subsequent recurrence

and are usually only necessary in the case of those growths which in the first place might be considered by some to be too large for treatment by this method

A month should elapse between successive treatments so that all the sloughs may have separated and the healing processes have advanced as far as possible, the application of the current to necrotic tissues should be

avoided. It is very interesting to note how much the growth will shrivel if the burning is not completed at the first operation, occasionally this does not take place, in fact it may even appear to have increased in size, under these circumstances the suspicion of the existence of a malignant condition should arise, and a suprapubic removal should be advocated. The difficulty



A



B



C

FIG 406—Illustrates (A) a very large papillomatous mass composed of five different segments which was successfully dealt with. The process of destruction took two hours (B) shows the condition of affairs as observed a fortnight after the first application the slough is seen with a portion of growth this was cauterized with the result shown in (C) a fortnight later. This case was treated seven years ago and has had no recurrence at the site of this growth. Two and a half years ago another growth appeared on the opposite side of the bladder which was readily dealt with without subsequent return.

of distinguishing clinically between innocent and malignant papilloma has already been referred to. The above-mentioned point was well illustrated in a recently-treated case in which the growth was considerably larger at the second sitting than when first seen, its subsequent removal proved it to be a carcinoma with early infiltration of the muscular coat.

Sometimes difficulty is experienced in destroying the base of the pedicle owing to the toughness of its structure, the effect of the coagulation of its surface and of an area for one-eighth of an inch of the normal mucosa around may have the desired result, but if this fails further treatment may be required.

The subsequent immediate history of these cases as a rule is uneventful. It is rare for the patients to experience any pain after the operation, beyond a certain degree of soreness during the act of micturition as the result of prolonged retention of the cystoscope in the urethra. In no case has a urethritis been set up. Occasionally there is pain referred to the tip of the penis at the end of the micturition, lasting for a few days, presumably caused



FIG. 407.—Illustrates one of the advantages of the method. Three papillomatous masses (A) were seen in the neighbourhood of the right ureteric orifice, which could not, however, be seen. A portion of the front growth was burned away, when a fourth small papillomatous mass was observed extruding from the ureteric orifice. (B) shows a close view of this. The bladder growths have been completely destroyed, and it can now be demonstrated that this papilloma is of ureteral origin, as it is sometimes withdrawn into its lumen.

by the œdema which spreads on to the trigone from the cauterized area. Cystitis is said to occur occasionally, but in my experience there has not been a single case, moreover, the urine has never shown evidence of infection.

The end-results observed are well illustrated in *Fig. 405*. In some of the other pictures similar appearances are seen, but the process of healing has not advanced quite so far at the time of the observation. At the end of two months it is usually difficult to find the scar. The mucosa sometimes becomes puckered as shown in *Fig. 406*.

Forty-eight hours is the average time required for the patients to be in bed, but in some cases it is not necessary for them to do so for a longer period than that required for recovery from the anæsthetic. On general principles the ulceration should heal more quickly if the patient rests for a

week while the acute inflammation subsides, and it is my belief that it does so. On the other hand, it has not been my experience that any harm has arisen when the patient has got up early.

It is of the greatest importance that the patient should be kept under observation. A cystoscopic examination should be made at least every three months after the growth has been destroyed and sound healing has followed. This is done for at least two years. Longer intervals are permitted after that period has elapsed without recurrence. Small growths can be so easily dealt with that it is worth it to the patient.

There are some difficulties met with during the operation. They chiefly relate to the size, position, and number of the growths. Fortunately, the majority of the papillomata are single, and situated near the ureteric orifices—a site easy of access, but those placed far back on the posterior wall, on the



A



B

FIG 408—Shows a small papilloma (A) with (B) the appearance seen a fortnight after the fulguration. This was dealt with five years ago and there has not been a recurrence.

vertex on the anterior surface, and around the internal meatal orifice, are difficult to treat owing to their inaccessibility. The cystoscope of Swift Joly, with the recurved guide for the terminal, has helped to eliminate some of these troubles, but not all of them.

This method is not applicable to the treatment of very large growths, owing to the fact that the cystoscope becomes embedded amongst the villous processes almost immediately on entering the bladder, which completely obscures the view, moreover, even if they can be seen, and persistent bleeding does not result from the introduction of the instrument, the length of time required to burn them would be considerable. These have to be treated through a suprapubic incision, their removal being effected preferably by diathermic cauterization, subsequent cystoscopic observations will enable any recurrences to be dealt with in the early stages.

Multiplicity of growths does not of itself constitute a contra-indication to the method, among my cases is one of a man who had eleven papillomata,

all of small size, of which ten have been successfully dealt with, the eleventh growth presents a curious difficulty not met with previously, it is situated on the left lateral wall, at some little distance from the ureteric orifice, as soon as the current is turned on after embedding the terminal, the left leg kicks violently and throws the growth out of view

At times the presence of an intravesical prostatic enlargement renders the growth inaccessible

The presence of cystitis is a contra-indication, as the sloughing tissues constitute a fresh focus for infection. This, however, seldom exists with the innocent varieties of papillomata, although commonly associated with the malignant group, to which, as has been stated already, this method of treatment is not applicable

Perhaps one of the greatest disadvantages of this method of treatment is the length of time required for the performance of the operation. The small growths can be quite readily dealt with, but if the growth is of any size a sitting may last a considerable period, depending not only on its dimensions, but also on the toughness of its structure. The advantages, however, so far outweigh those of suprapubic removal, that the trans-urethral method is to be preferred, and in my opinion should be used as the routine procedure for the treatment of innocent papillomata

SHORT NOTES OF RARE OR OBSCURE CASES

FOREIGN BODY IN THE APPENDIX

By J. H. MATHER, LIVERPOOL

The following case is of interest on account of the nature of the foreign body, and as showing the value of X rays as an aid to diagnosis.

The patient, a woman, age 25, was admitted to the Royal Southern Hospital on Aug. 10, 1922, complaining of attacks of severe pain in the abdomen. For the past ten years she had suffered from intermittent attacks of pain in the right side of the abdomen, which were gradually becoming more frequent and severe. She had attended a hospital for women, and two years previously had been operated on for "misplaced womb and enlarged ovary." The patient stated that the attacks of pain persisted exactly as before the operation, and she continued to attend as an out-patient, receiving treatment for this obscure right-sided abdominal pain until her admission.

For the ten weeks previous to this she had approximately one attack each day, the pain being sometimes very severe. She had never vomited.

On examination the patient complained of pain on palpation round to the loin.

On Aug. 17, she was sent to the X-ray department for examination of the urinary tract for possible calculus. The radiographs showed both kidney shadows, not enlarged or displaced, and no stones were present. On the right side of the pelvis, however, at the level of the iliac crest a pin was shown, around the head of which was a shadow suggesting a concretion. This,

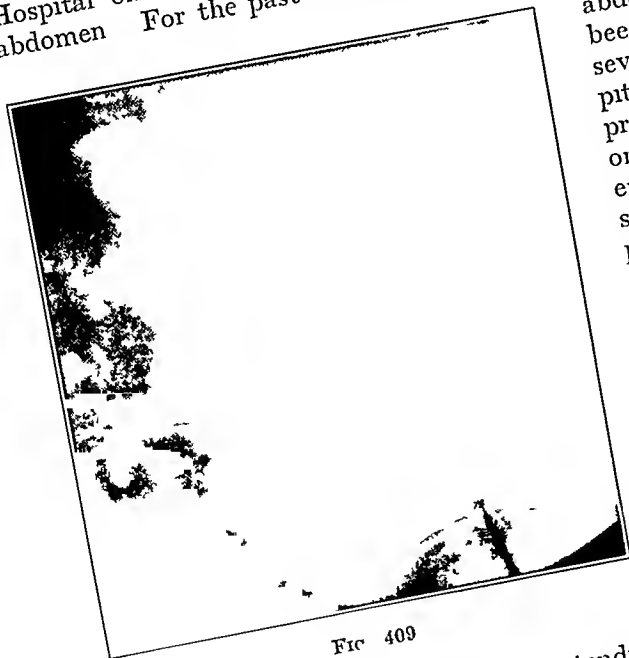


FIG. 409

together with the fact that the pin changed its position in the two radiographs (*Figs 409 and 410*), pointed to its being in the abdominal cavity

A bismuth meal was then given, and, on examination of the abdomen twenty-four hours later, the pin could be seen just below the cæcum (*Fig 411*). On palpation it could be moved with the cæcum and a diagnosis of pin in the appendix was made

At the operation Mr Herbert Williams found the pin the head with a surrounding concretion being in the lumen of the appendix, the pointed end had ulcerated through the wall of the appendix and was sticking into the iliacus muscle, the whole being surrounded by adhesions. The pin was very much corroded and this, with the hard concretion, pointed to its having been in this position a considerable time



FIG 410



FIG 411

VOLVULUS OF THE STOMACH

BY HUMPHREY NOCKOLDS LONDON

ON May 11, 1923, a married woman, age 42, was admitted to Lewisham Hospital with the following history —

She was said to have suffered from gastric ulcer when a girl many years ago, but had for years been quite well until fourteen days before admission. She vomited before getting up one morning. She got up and did her house-work, but 'felt weak', and for the ensuing four days she vomited all her food and then on the fifth day commenced vomiting continuously, anything she took being brought up at once. The vomit was watery and almost clear, containing no bile and the quantity was greater than the volume of fluid taken in. She insisted on going on with her work. The day before admission she became light-headed, but was still refusing to go to hospital. By this

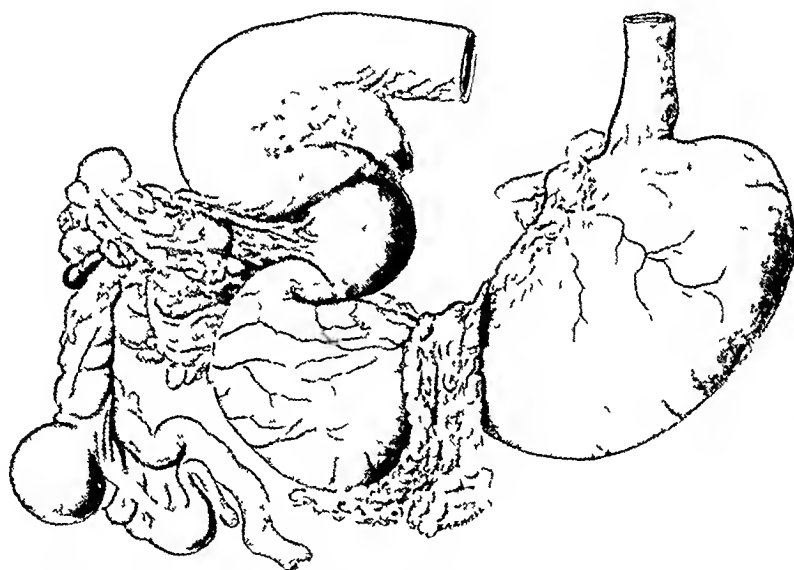


FIG. 117.—Complete rotation of lower portion of hour glass stomach below an old healed ulcer.

time she was too weak to get out of bed. Dr. C. T. Comber, who was her medical adviser, saw her five days before admission, when she complained of acute indigestion, with pain and vomiting after food, and epigastric tenderness. She had absolute constipation for four days before admission.

On admission the patient was moribund and unconscious. Examination of the abdomen revealed nothing except an increase of the stomach resonance. The urine contained a fair amount of albumin. Temperature, 97.4° . Pulse small and running 130. She died about twelve hours after admission, and it was thought that it might be a case of uremia.

Post-mortem Examination—When the abdomen was opened it was seen that the stomach was divided by a constriction into two portions, the upper

one being greatly dilated. The condition is well shown in Fig 412. The upper segment measures 17 cm (in the prescised state) and the lower segment 10 cm in length. This constriction was partly caused by the rotation of the lower portion of the stomach about a vertical axis from left to right through 360°, forming a complete circle, the great omentum (which is extremely thin) being involved.

Examination of the inside of the stomach shows old healed ulcers on the lesser curvature giving rise to an hour-glass stomach, the lower portion of the hour-glass having rotated just below this ulcer. The lower turn has taken place about half an inch below the pylorus in the first part of the duodenum. The stomach wall of the upper segment is much thinner than the lower, which is intensely congested and has its mucous membrane bile-stained. Dr J W McNee very kindly had sections cut for me from the old ulcer. They show much scarring and fibrosis in the submucous coat, but the mucous membrane has grown again over the site of the ulcer. The pylorus was thick and well developed.

An excellent account by Max Thorez of volvulus of the stomach appears in the *Journal of the American Medical Association*, August 25, 1923. According to this paper there appear to be recorded 31 cases of volvulus of the stomach, this case being therefore the 32nd.

Kocher in 1914¹ reports 28 cases. Since then there have been cases by Niosl, and Siegel and Thorez.

The specimen is in the museum of University College Hospital, London.

REFERENCE

¹"Ein Fall von Magenvolvulus", *Deut Zeits f Chr* 1914, 127, 571.

A CASE OF CARCINOMA OF THE BREAST: DEATH 13½ YEARS AFTER OPERATION FROM DIFFUSE SECONDARY DEPOSITS.

By CECIL P G WAKELEY, LONDON

This case is recorded because of the long interval between the time of the original operation and that of secondary deposits occurring in the liver, also because, once secondary deposits are clinically present in the liver, the average lease of life is about eighteen months. In this case the liver became enlarged and palpable in 1920, and death took place in October, 1923—that is three and a half years later.

HISTORY.—The patient, E. D., age 36, was admitted to King's College Hospital under Mr. Bughard in May, 1910, with a hard tumour, about the size of a pigeon's egg situated in the upper and inner quadrant of the right breast. It was stony hard and was attached both to the skin and the pectoral fascia. The patient stated that she had noticed a lump in the

breast for six months. On May 24 a radical amputation was performed, both pectoral muscles and the axillary glands were removed. The wound healed well. On section the growth was a typical spheroidal-celled carcinoma of the scirrhus type. The axillary glands were invaded with growth. The patient remained well until June, 1912, when a few secondary nodules appeared in the scar, these were excised, and were found to contain growth similar in nature to that of the primary focus which had been removed two years before.

In 1913 a few small glands were palpable in the axilla, these were excised, and on microscopical examination were found to be invaded with carcinoma.

In 1917 two small glands were noticed in the right supraclavicular triangle, these were completely removed, and on section were found to be invaded with malignant disease. The patient seemed in good health and undertook the work of a busy household.

In 1919 another gland was palpable in the supraclavicular region, it was situated just above the clavicle, on removal it was found invaded with growth. X-ray treatment was commenced in December, a pastille dose with a 1-mm filter was given each week to the whole of the area from which the breast had been removed, and, in addition, one pastille dose was given to the supraclavicular triangle.

In February, 1920, the liver became enlarged below the costal margin, and secondary deposits could be palpated on its surface. Weekly treatments of one pastille dose were now given as regularly as possible both to the liver area and to the area of the right breast. The liver slowly increased in size, but the patient appeared to be very well and still continued her household duties.

In July, 1921, the liver was about three finger-breadths below the costal margin. The patient went away for two months to the seaside, and came back for further X-ray treatment looking very well.

In the middle of 1922 she developed a cough which proved rather troublesome. A skiagram of the chest did not reveal any secondary deposits. She went to Devonshire for three months and came back stating that her cough had disappeared. X-ray treatment to all areas was resumed, the liver had increased so that it was now five finger-breadths below the costal margin.

In July, 1923, the patient became blind in her left eye, this was thought to be due to a secondary deposit involving the optic nerve. In September ascites was first noticed. The fluid rapidly accumulated and, owing to embarrassment to the heart, paracentesis abdominis was performed on Oct 2, 1923, 10 pints being withdrawn. The condition of the patient improved somewhat for a week, but coma supervened, and she died a few days later.

POST-MORTEM EXAMINATION—At autopsy the liver occupied nearly the whole of the abdomen, it weighed 13 lb 6½ oz. The whole of the surface was nodular. On section, patches of fatty degeneration could be seen between the nodules of growth. There was a small growth on the surface of the left lung. Both ovaries were enlarged, hard, and nodular, and each was about the size of a hen's egg. On section, areas of solid growth could be seen. The other organs were normal. An examination of the brain was not permitted.

MICROSCOPICAL EXAMINATION—The liver revealed typical secondary scirrhous carcinoma. The nodule in the left lung revealed a carcinomatous growth of the scirrhous type infiltrating along the subpleural lymphatics. The ovaries showed extensive carcinomatous deposits of the scirrhous type.

The patient had received 248 pastille doses of X rays during the treatment, of which 125 were given over the liver area.

INTUSSUSCEPTION OF THE SIGMOID

3½ YEARS AFTER AN INTUSSUSCEPTION OF THE APPENDIX

By A. J. BLAXLAND, Norwich

In the *BRITISH JOURNAL OF SURGERY* of October 1920, I recorded a case of intussusception of the appendix occurring in a man of 63. The appendix was completely inverted, its mucous surface being studded with malignant



FIG. 413.—Malignant papilloma of appendix ($\times 15$)

papillomatous growth, and it was lying within the transverse colon, having drawn up the ascending colon, the caecum, and part of the ileum with it. The intussusception was reduced, with the exception of the appendix, which was removed by incising the caecum round its base.

Three and a half years later, on Nov. 5, 1923, the patient was sent into the Norfolk and Norwich Hospital by Dr. Palm of Fakenham, with intestinal obstruction of three days' standing, and passing blood per rectum. There was marked distention of the abdomen, and on rectal examination a swelling resembling an oedematous os cervicis could be felt high up.

Laparotomy revealed an intussusception of the pelvic colon. The bowel was invaginated for 6 inches, and after reduction, which was performed without great difficulty, the cause of the intussusception was found to be a protuberant malignant ulcer—about 1 inch in diameter—situated in the wall of the upper part of the pelvic colon. I performed a resection, closed the distal end of the bowel, and inserted a Paul's tube into the proximal end. Uneventful recovery ensued, except that during convalescence (as after his previous operation) he suffered from an attack of acute gouty arthritis.

The growth on section proved to be a malignant papilloma—similar in character, microscopically, to that which had affected the appendix, as is shown in the accompanying microphotographs (*Figs 413, 414*). Apart from



FIG. 414.—Malignant papilloma of sigmoid ($\times 15$)

the rarity of a chronic intussusception of the large bowel occurring twice in an old man within a short time, the interest in this case seems to me to lie in the question as to whether the sigmoid growth was a primary one, or whether it was secondary to the papilloma of the appendix. If the latter, it was presumably due to implantation, but three and a half years seems a very long time for it to have taken to make its presence felt. In my experience secondary growths, which arise by implantation, are rapid in growth and are usually multiple and situated within a short distance of the primary lesion. I am inclined therefore to believe that this case is one of a second primary malignant growth.

I am indebted to Dr. Claridge, Pathologist to the Norfolk and Norwich Hospital, for preparing and reporting on the microscopical sections, and to Dr. Hutchinson, of Lowestoft, for the excellent microphotographs.

ACUTE INTUSSUSCEPTION IN A FEMORAL HERNIAL SAC.

By CECIL P G WAKELEY, LONDON

ALTHOUGH intussusceptions in hernial sacs have been occasionally described, the condition is a rare one. The following case is interesting because the hernial sac was bilocular and the inner sac was of enormous dimensions.

Mrs A H, age 81, was admitted to King's College Hospital on Dec 11, 1923, with a very large strangulated femoral hernia on the right side. The patient had been operated upon at St Thomas's Hospital for right femoral hernia five years previously. The hernia had recurred about a year after the operation, and had gradually become larger, but had never given rise to intestinal obstruction. The patient was quite well until the evening before admission to hospital, when, while walking upstairs,

she was suddenly seized with pain in the right groin. She noticed that the rupture was hard and painful, her bowels had been well opened about three hours previous to the attack. The patient vomited three times during the night, and the pain became somewhat lessened. The next morning she was brought up to hospital and admitted.

On examination, a large bilobed swelling was seen below Poupart's ligament on the right side. The upper and outer portion of this swelling was resonant on percussion, and extended upwards towards the anterior superior iliac spine. The lower and inner portion of the swelling extended halfway down the thigh (*Fig 415*), and was dull on percussion.

Operation was performed at once, a long curved incision was made over the larger swelling, and the hernial sac opened. It was found to contain an

intussusception of the enteric variety, which was reduced with difficulty. This having been effected, another hernia was found in the upper part of the bilobed sac, this was reduced with ease. The large sac was excised, and its upper portion used to plug the enormous crural opening. A drainage tube was inserted into the thigh, as there was a large raw surface left after excision of the large hernial sac. The patient, in spite of her advanced age, stood the operation well, her bowels were opened every day after operation. However, bronchopneumonia became evident on the fourth day, as a result of which complication the patient unfortunately died. Autopsy was refused.

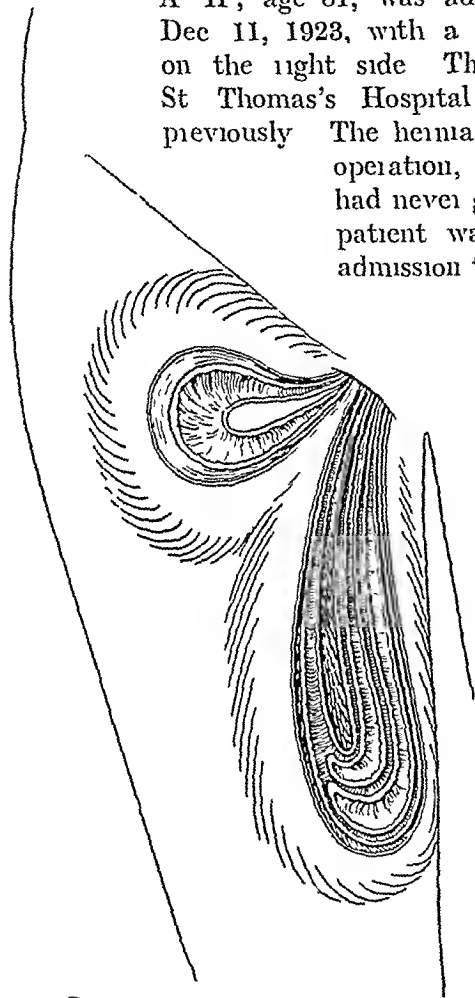


FIG 415.—Intussusception in a bilocular femoral hernial sac

CARCINOMA OF SOLITARY KIDNEY WITH OTHER COMPLICATIONS

By M B HANNAY, PAISLEY, AND ROY F YOUNG, GLASGOW

MRS J W, age 52, was admitted to the Royal Alexandra Infirmary, Paisley, suffering from chronic intestinal obstruction of six weeks' duration, presumably due to a tumour in the hepatic region. Examination revealed abdominal distention with visible peristalsis. A large tumour of renal origin was felt in the right lumbar region. The diagnosis was made of malignant disease of the right kidney, with resulting obstruction of the ascending colon. Partial relief was obtained by enema.

The urine was acid, 1016, clear, with deposit of urates on standing, there was a trace of albumin. Microscopic examination showed leucocytes, a few red blood-corpuscles, calcium sulphate crystals, and a few hyaline, granular, and cellular casts.

Five days after admission, as the obstruction remained unchanged, operation was carried out with a view to relieve this. The obstruction was found to be caused by an enterolith in the transverse colon, behind which the bowel was hypertrophied and dilated. As the enterolith could not be passed on, it was removed through an incision in the bowel. At the time of operation some enlarged glands were felt in the mesentery.

REPORT ON ENTEROLITH (M B H)—The specimen measured $1\frac{1}{2}$ by $1\frac{1}{8}$ inches in diameter, and weighed 24 gm. It cut easily, and was of the same consistency throughout, the cut surface having a yellowish-white appearance. There was no crystalline matter. Microscopically it consisted of amorphous debris, some of which was bile-stained, and there was much fatty matter, apparently in the form of soap. The general characters suggested that it consisted of dried faecal matter.

The patient made an uninterrupted recovery from operation, but four days later 'menstruation' began, for the first time for six months. Nine days later there was free bleeding from the vagina. A catheter was passed into the bladder, and practically pure blood was drawn off. At the same time, however, it was noticed that blood was coming from the vagina also. The bleeding continued intermittently, and the patient gradually failed, and died twelve days later.

POST-MORTEM EXAMINATION—The following is the report of the post-mortem examination (M B H). Emaciation. Hypertrophy of heart (16 oz.), with some dilatation of the right ventricle. Old pleuritic adhesions scattered on right side, general on left. Some calcareous tuberculous glands in the mesentery. A mucous polypus, attached to the cervix uteri, protrudes through the os, the diameter of the protruding part being about that of a shilling. There is hypertrophy of the right kidney, which is in its normal situation. The hepatic flexure crosses the lower pole of the kidney. The right ureter enters the bladder at its usual site. The left kidney and ureter are absent.

The kidney weighs just over $1\frac{1}{2}$ lb, and measures $7\frac{1}{2}$ by $4\frac{1}{4}$ by $2\frac{3}{4}$ inches in diameter. On bisection, the greater part of the lower pole is yellow in

colour and somewhat caseous in appearance, nodular on the surface, and contains some white fibrous-looking areas, as well as a few small hæmorrhagic patches. This yellow area is not encapsuled, and there are outlying small areas near it, as well as in the upper half, where a similar condition seems to be commencing at two points. The pelvis is hypertrophied, much dilated (about 1 inch in diameter), and filled with clot. There is a thickened area in its wall where it joins the ureter, presumably a secondary growth. The ureter is slightly hypertrophied, much dilated, and measures approximately $\frac{1}{2}$ inch in diameter.

Microscopically the yellow mass in the lower pole is a new growth composed of large alveoli lined by proliferating epithelial cells and separated from one another by little more than thin-walled capillaries. There are areas of necrosis. The growth is not encapsuled, and shows a tendency to infiltrate the kidney substance at its margin. The general characters are those of a carcinoma.



FIG. 416.—Photograph of the kidney, on section. The tumour is at the lower pole.

COMMENTS.—According to Morris, as quoted by Thomson-Walker, the frequency with which unsymmetrical kidney occurs is about 1 in 2400 bodies, and the left kidney is more frequently absent than the right. I have been permitted to examine the post-mortem reports in the Royal Hospital for Sick Children, Glasgow, since 1915. In 1411 cases there was one case of unsymmetrical kidney (No. 387). In this case the left kidney was present and was larger than usual. On the right side there were neither kidney, ureter, nor renal vessels. Other developmental defects were present, namely imperforate anus and hypospadias. In the case reported here, there were no other developmental defects. Such solitary kidneys are said to be specially liable to be attacked by disease.

REVIEWS AND NOTICES OF BOOKS

Exploration Clinique et Diagnostic Chirurgical By FELIX LEJARS, Professor of Clinical Surgery at the Faculty of Medicine, Paris, Surgeon to l'Hôpital Saint-Antoine. Royal 8vo. Pp 778, with 907 figures, 1923. Paris: Masson et Cie. Sewn, 50 francs; bound, 60 francs.

It may safely be said that the reputation of the author of *Urgent Surgery* as a lucid and practical writer is fully maintained in this new work, which deals exhaustively with the various methods of regional examination with a view to arriving at a surgical diagnosis.

In his preface the author very rightly points out that, although at the present day the various physical, chemical, and bacteriological methods are of the greatest service, they have taken away nothing from the value of the traditional methods. The object of the book is thus a very commendable one, for it must be allowed that at the present time there is a great tendency to place an undue share of the responsibility of arriving at a surgical diagnosis upon laboratory methods, and the student is too apt to resort at once to these aids before, instead of after, he has exhausted all the ordinary methods of clinical examination. The work, which forms a very handsome volume, is profusely illustrated by original figures collected for the purpose during many years, and in the case of those showing methods of examination the author tells us that in each instance they were taken from patients actually suffering from the affection concerned.

The arrangement of the book is of course regional, and, although the attention of the reader is chiefly directed to the more common diseases and injuries in each part, the more rare conditions receive due notice. The style is conversational, and the reader is made to feel that the patient is actually before him.

The longest section deals with the abdomen, and by comparison the sixteen pages devoted to the cranium seems inadequate, and it is unfortunate that this section, which is the first in the book, should be the least satisfactory.

In a work dealing with all aspects of differential diagnosis it is inevitable that some omissions should occur and that some of the methods should be open to criticism. We can find no mention of actinomycosis, which certainly deserves consideration in dealing with affections of the neck and right iliac fossa.

In examining tumours of the breast, the author does not appear to us sufficiently to emphasize the importance of examination in the recumbent position, and, indeed, in nearly all the figures the patient is represented as erect. Clerical errors are extremely few, but McBurney becomes "Mae Burney" and Bryant's triangle is the "triangle of Bryan."

The book is a mine of practical information, and should prove a very worthy companion to the *Traité de Chirurgie d'Urgence*.

Elements of Surgical Diagnosis By SIR ALFRED PEARCE GOULD. Sixth edition, revised by Eric Pearce Gould, M.D., M.Ch., F.R.C.S., Assistant Surgeon to the Middlesex Hospital, Surgeon to the Bellingbroke Hospital. Small 8vo. Pp 739 + xvi, with 20 radiographic plates. 1923. London: Cassell & Co. Ltd. 12s. 6d. net.

This work, which was first published as long ago as 1884, is so well known to require any detailed review. The present edition is largely modelled on the original, but some re-arrangement and much careful revision has been carried out, while its usefulness has been enhanced by the insertion of some fifteen new radiographic illustrations, most of them excellent.

If students ever read the Preface, their attention will be arrested by these words "With the striking exception of the diagnostic use of X rays, the progress of surgery since this book was first published has done little to provide short cuts to the diagnosis of surgical affections, and accuracy and confidence in diagnosis are still to be attained only by methodical and complete examination." The manual is a sure guide to the attainment of this object, and the preliminary chapter on "Method in Diagnosis" is full of wisdom.

There are some few matters which merit adverse criticism, and it would be well if the author in a future edition would delete the ugly word 'hydro-sarcocele' or would give its meaning. Similarly it would be helpful if the word 'trismus' were defined at the commencement of the section dealing with the temporo-mandibular joint. In discussing the conditions that may be mistaken for abdominal tumours, the author has evidently forgotten the story of Commodore Truncheon's lady, or pseudocyesis would have been more specifically mentioned.

It is a pleasure to remark on the way in which the book has been turned out by the publishers and the pleasure is enhanced by the information that it has been done in Great Britain. The paper, print, illustrations and binding are alike excellent.

The Effects of Radium upon Living Tissues with Special Reference to its use in the Treatment of Malignant Disease By SIDNEY FORSDIKE, M.D., B.S., F.R.C.S., Surgeon to Out-patients, Hospital for Women, Soho Square. Demy 8vo. Pp. 72 + viii, with 42 illustrations. 1923. London. H. K. Lewis & Co. Ltd. 5s. net.

This monograph is the subject matter of an essay for which the author has received the Jacksonian Prize. Under the above ambitious title we find compressed a fairly complete summary of the present position of radium as a curative agent in malignant disease, and particularly in relation to carcinoma of the uterus. The author introduces the work with a brief reference to the discovery of radium, and its physical properties, devoting a few paragraphs to the bearing of the latter upon the practical part of the work.

The physical section of the book is necessarily very elementary in character, but it suffices to throw some light upon the reason for the changes which are recorded in the more critical analysis of the changes induced in normal and morbid tissues.

The record of the action of radium rays upon the normal tissues is given in a number of experiments upon the ovary of cats. This part of the work is painstaking and reliable, the author succeeds in demonstrating a good deal of what is already well known, but it loses none of its value on that account, since corroboration of these changes is always valuable. One fact stands out prominently: all of the tissues examined showed changes due to the action of the radium, and in no part of the work does it show definitely that a specific selective action exists for any particular tissue.

A careful description of the technique, both in regard to the normal tissues and to carcinoma, is worthy of commendation as a concise and straightforward description of a technique which might be regarded as a standard for other workers.

Next follows a detailed summary of the treatment of fifty cases of carcinoma of the cervix uteri. Three of these were regarded as operable, forty-seven as inoperable. One of the operable cases died, the other two were alive eighteen months after the treatment, clinically they were free from the disease. The author wisely refrains from any statement of value in these cases.

Forty-seven inoperable cases. "All of these cases were too advanced for operation, many of them being within measurable distance of the termination of life, nevertheless, where there was any prospect of relieving pain, hæmorrhage, or offensive discharge, they were irradiated." From the point of view of palliation he succeeds in showing how effective radium can be when a good technique is followed. Discharges ceased and ulcerated surfaces healed, and the patients, for a time at least, were made more comfortable.

Dr. Forsdike is thoroughly conservative in his statement of the value of radium and X rays in the treatment of carcinoma, though he says that in rodent ulcer and

in sarcoma radium has succeeded in curing these conditions without a peradventure. This statement is open to question, a great deal depends upon what is regarded as a cure. In relation to carcinoma, he states that for late cases of cancer there is no comparison with any other treatment known. The claim is advanced that in 80 to 85 per cent of cases the symptoms are relieved with the minimum amount of invalidism, and that the patient is enabled to pursue her daily round without inconvenience to herself and without being a nuisance to others. This is obviously an optimistic view to take of the value of radium, particularly as many of his cases were admittedly not only in an advanced condition, but also complicated by sepsis. Dr Forsdike also omits to state for how long his cases were enabled to pursue an ordinary daily course of life.

He concludes his summary by the pertinent question, Are we to continue to treat only inoperable cases? Dr Forsdike is competent to answer the question, he has the knowledge of radium and its effects, he knows the results he has obtained and he is a competent gynaecologist. Does he recommend operation or radium for the early cure of cervical carcinoma?

The book is well illustrated by half-tone reproductions of a large number of sections from normal tissues and from the series of cases of carcinoma in which the treatment by radium was carried out. It is recommended as a reliable guide for those wishing to try radium in suitable cases, and it should be useful to operating gynaecologists, if only for the service it renders in pointing out that radium is undoubtedly a valuable adjunct to the better-known methods of treatment, and one which offers a measure of relief to those patients who are beyond the reach of surgery.

The Diagnosis and Treatment of Acute Abdominal Diseases By JOSEPH E ADAMS, M.B., M.S., F.R.C.S., Surgeon to St Thomas's Hospital. Second edition. Demy 8vo. Pp 558 + 1, with 46 illustrations. 1923. London. Baillière, Tindall & Cox. 16s net.

WE consider this book a just presentation of the subject which cannot fail to be of service to those who consult it. There are sixteen chapters. The first gives a useful resume of the main features of the surgical anatomy of the abdomen, the second treats of the method of investigating acute abdominal diseases, the third deals with the details of the technique of laparotomy, whilst the remainder of the book is devoted to the various groups of diseases, for the most part grouped anatomically. The last chapter is a most useful one, dealing with diseases which may simulate abdominal lesions. We are in accord with the author when he states "If after a complete investigation of the case there is any real doubt as to whether to open the abdomen or not, explore." The inclusion of a special chapter dealing with the general post-operative complications is worthy of the author's consideration.

In a subject which is so extensive it is inevitable that we should find some points of difference. We are not "entirely opposed to exploratory puncture as an aid to the diagnosis of subphrenic abscess", though we recognize that such a method has its limitations and even dangers. In dealing with the subject of acute appendicitis without peritonitis, the remark is made that "rigidity is always present in some part of the right iliac fossa in the acute stage of the disease", we can only comment that frequently there is no trace of rigidity demonstrable at the time of examination, and with a pelvic appendix it is the rule not to have any rigidity unless there be peritonitis.

Under the heading "Constitutional signs of obstruction" the author begins by stating, "The face is pallid and shrunk, the expression anxious, the complexion muddv." These are surely late symptoms which it is perhaps misleading to indicate as usual in the stage at which we all like to see such cases.

In a book which has so recently been revised, we should have liked to see some reference to Barnard's classical account of the course of intestinal obstruction by a gall-stone, and to McCartney and Fraser's recent work on pneumococcal peritonitis.

We are glad to see that the author recommends the division of Poupert's ligament in some cases of strangulated femoral hernia, and consider that his advice to use scissors instead of a hernia-knife is good.

Orthopædic Surgery By ROYAL WHITMAN, M D, M R C S, F A C S, Surgeon to the Hospital for Ruptured and Crippled, etc. Seventh edition, revised Pp 993 + vii, with 877 illustrations 1923 London Henry Kimpton 42s net

DR ROYAL WHITMAN'S *Orthopædic Surgery* remains, in spite of recent rivals, the most complete text-book on the subject, valuable alike to student, practitioner, and specialist. The best section of the book is that part which deals with tuberculous diseases of bones and joints, in particular the clinical account of the symptomatology and diagnosis of these conditions. In this section the accounts are so full and so accurate that they deserve to be studied by all practising surgeons, and they certainly form a most valuable text for a student to read. There is little that is new in this section, and perhaps some of the descriptions of mechanical methods might at the present time be omitted, but the whole account of tuberculous diseases is so complete and up to date, and also so fair in its discussion of different methods, that it would be difficult to find its equal in any other volume.

In the other sections the author's own work and methods naturally appear more prominently than do those of other surgeons but even here there is on the whole a very fairly complete discussion of methods of all sorts. The only criticism that can be made is that perhaps physical methods of treatment, as apart from operative and mechanical, are too briefly described, and are given less prominence in orthopædic treatment than they deserve at the present time.

The principles of re-education of muscles and of posture are too little insisted upon, and such exercise treatment as is described, for example, under scoliosis, would be considered very old-fashioned by most present-day authorities on the subject. The set of dumb-bell exercises for scoliosis is still included, and Teschner's opinion is given that in the treatment of this deformity a general strengthening of the whole muscular system is indicated. It is to be feared that treatment on these lines too often results simply in a fixation of the existing deformity without correction.

The section at the end on collateral orthopædic surgery is in its present form rather diffuse, and the selection of items for description, and their order are irregular. Possibly in some future edition the author may feel inclined to incorporate much of this work, which includes a very large and important section of orthopædic surgery in the rest of the volume, putting each item in its proper place. In fact, although the matter of the book is excellent, the general plan upon which it is arranged is open to criticism. It gives the impression that a book written now some years ago has been revised from time to time by addition and substitution without any real attempt to rearrange matter in accordance with modern ideas and methods. The printing and illustrations remain up to the original high standard.

Le Sympathique Cervico-thoracique By Prof THOMAS JONNESCO. Large post 8vo Pp 92, with 34 figures and 10 plates in colour, and black and white 1923 Paris Misson et Cie Fr 42

IN this monograph Professor Jonnesco records the work of twenty-five years upon the surgery of the cervical sympathetic. It is divided into three main sections, the first dealing with anatomy and physiology, the second with surgical technique, and the third with the clinical aspects of the subject. It is well illustrated and contains a useful bibliography.

The operation described entails the removal of the whole cervical sympathetic chain. The early operations of Jaboulay for exophthalmic goitre (1896) and his own for epilepsy (1896) were, he holds, unsuccessful because they were too limited, and in his opinion a successful operation must include the inferior ganglion and with it necessarily the first thoracic ganglion. A bilateral operation has been carried out in some cases. The serious results recorded by physiologists as following sympathetic resection in animals do not occur in man. The operation is carried out under high spinal anaesthesia for which a mixture containing caffeine, benzoate of soda, and stovaine is employed.

The conditions which Jonnesco has treated by sympathectomy are exophthalmic goitre, epilepsy, migraine, trigeminal neuralgia, angina pectoris and glaucoma.

Fifty cases of exophthalmic goitre, so treated, are quoted in some detail. There were but four deaths immediately following the operation. Of the 46 surviving patients, 8 who were followed for periods of from nine to twenty-four years were completely cured, whilst in the remainder the immediate benefit was very great. So enthusiastic is Jonnesco with regard to the results that he writes "Total bilateral resection of the cervico-thoracic sympathetic is the only rational operation in the treatment of exophthalmic goitre."

For epilepsy the operation was done in 130 cases, with one death. Twelve patients were 'cured', and amongst these there were two who were followed for twenty-three and twenty-five years respectively, during which time no fit had occurred although the epilepsy had existed, previously to the operation, in the one case for four years and in the other for three years.

As regards inguina pectoris, the pain of which is ascribed to the sudden hypertension of the aorta or left ventricle, and is said to be conducted by the sympathetic by way of the stellate ganglion, 6 patients have been operated upon, with 2 deaths. The cases are related in detail, and the results appear to have been very striking, one patient being well seven years later.

The results obtained in migraine, trigeminal neuralgia, and glaucoma do not appear to be such as to encourage the employment of Jonnesco's operation for those conditions. It would seem, however, that as regards exophthalmic goitre and angina pectoris Jonnesco's claims are sufficiently well established to deserve the careful attention of those who are interested in the treatment of those conditions.

The Students Handbook of Surgical Operations By SIR FREDERICK TREVES, BURT G C V O, CB, LL D, F R C S, and JONATHAN HUTCHINSON, F R C S, Consulting Surgeon to the London Hospital. Examiner in Surgery, Glasgow Royal University. Fourth edition, enlarged. Pp 552 + ix, with 167 illustrations. 1924. London Cassell & Co Ltd 10s 6d net.

THIS well-known handbook has been somewhat enlarged and altered since the last edition. It still remains chiefly a guide to operations on the dead body, and the amount of space given to a description of ligature of arteries and amputations is quite out of proportion to the practical value of these operations. The claim which is made in the preface to include modern operations of practical importance is not fully borne out in the text. For example, while the preface distinctly states that operations for displaced semilunar cartilages have been described, a careful search in the index and text fails to discover such description.

Le Cancer Thyroïdien By LÉON BEAIRD and CHAS DUNET. Royal 8vo. Pp 585, with 149 illustrations and 2 coloured plates. 1924. Paris. Doin. Fr 40.

THIS is one of a series of monographs on cancer published under the direction of Professors Hartmann and Beaird. Volumes on cancer of the intestine, kidney, and rectum have already appeared.

The book is an excellent one, and a model of what a surgical monograph should be. It is the most complete work on the subject that we have yet seen. It has been written by two Lyons professors who have worked for many years in a district where goitre is extremely common. They have consequently had unrivalled opportunities for the study of their subject. Their large experience, tempered with sound judgement, is reflected in almost every page of the work.

Beginning with a full, but necessarily condensed, historical survey, the authors proceed to give an excellent summary of the embryology of the thyroid. Then follow chapters on the anatomy, histology, and physiology of the gland, together with a brief account of thyroid cancer in the lower animals.

After a short account of the etiology and distribution of thyroid cancer, the authors deal fully with pathological anatomy, both macroscopic and microscopic. The difficulties of a correct classification of malignant tumours of the thyroid

are pointed out, and reference is made to the excellent work of Wölfler and of Langhans, the eminent professor of Beine, and others to whom all workers in this field of pathology are so much indebted. Modern classification of thyroid tumours is based upon the separation of the thyroid apparatus into its constituent elements as described in the chapters on embryology and anatomy (thyroid proper, parathyroid, post-branchial, etc.). They rightly point out that many, perhaps most, of the tumours hitherto described as sarcomas should more properly be classed as carcinomas. The puzzling 'mixed' tumours the rare squamous-celled carcinomas, and others are ably and fully dealt with. The existence of the oft-described 'benign metastatic goitre' is rightly we think, treated with scorn, such tumours being always malignant. A brief chapter deals with the difficult and little understood subject of the physiopathology and biochemistry of thyroid cancer.

We are now halfway through the book. The second half deals with the clinical aspects of the subject. An excellent and lengthy chapter is devoted to the symptoms of the classical form of thyroid cancer, including those of sarcoma. Then follow short but good chapters on acute cancer, ligneous cancer, latent cancer and cancer of aberrant thyroids. The difference between ligneous cancer and ligneous thyroiditis, so often confused with it, is fully discussed, and a somewhat amusing account is given (pp 412-15) of the great discussion on this subject at the Société de Chirurgie de Paris in 1901.

The next chapter deals at some length with the difficult subject of diagnosis. All who have had much practical experience will agree with the authors that we have at present no means of making an accurate and *certain* diagnosis of malignant disease of the thyroid, in its early stage, that is, while it is still confined within the glandular capsule, at that stage at which alone radical surgical treatment offers much hope of success.

The last chapter is devoted to treatment. The indications and contra-indications for radical treatment are discussed temperately and wisely. Detailed instructions for the performance of the various operations are given. Stress is laid upon the dangers and complications which may accompany or follow such operations. The limitations which the prudent surgeon should set himself in this distressing field of surgery are well described. The various palliative operations which are so often called for are well discussed. The difficulties, dangers, and frequently distressing results of tracheotomy are portrayed by master hands who know the truth of the pictures they have been painting.

The only weak point that we can find in the book after a very critical examination of it, lies in the illustrations, many of which are exceedingly poor. This is due partly no doubt, to the quality of the paper on which they are printed, but not wholly. The worst are those which deal with macroscopic pathological anatomy. Figs 30, 37, 38, 41, 43, for instance, show practically nothing, and the book would be better without them. The representations of microscopic sections are much better, and many of the photographs of patients are as good as can be expected in a work which is produced at so moderate a price. There is, unfortunately, no index.

We notice a good many misprints such as Hugues for Hughes (p 15), keste for Roste (p 32), pirathyroïde for parathyroïde (p 34), niveau for nouveau (p 66), bronchiaux for branchiaux (p 35). These are mostly quite trivial and do not detract from the general excellence of the book on which we congratulate the authors most heartily.

Cleft Lip and Palate. By THOMAS W. BROPHY, DDS, MD, Emeritus Professor, Chicago College of Dental Surgery, etc. Royal 8vo. Pp 344 + xxiv, with 466 illustrations and coloured plates. 1924. London: H. Kimpton. 30s net.

A book on any special branch of operative surgery written by one who has had long and extensive experience of that branch is always worth careful study. This volume is mainly a reprint of the chapters on these subjects in the author's earlier work on oral surgery published in 1915. Various additions, alterations, and improvements have been added to bring the book up to date and it doubtless represents Dr Brophy's latest views on the whole subject.

In the first page of the preface, referring to the surgical treatment of cleft lip and palate, the author states boldly "that the American and European medical colleges, even of the greatest repute, give little or no information to their students upon this subject" (the surgical treatment of cleft lip and palate). We are of the opinion that this sweeping accusation is scarcely justified, at least as far as British Schools are concerned, nor does our experience of American and Continental Schools lead us to think that they merit this reproach.

The volume is divided into six chapters of very unequal length. The first (comprising about one quarter of the whole) deals with hare lip, or, as the author prefers to name it, 'cleft lip'. After a short description of the various forms of hare lip, illustrated by photographs, he gives a careful, and on the whole a good, description of the ordinary operations for this deformity, rightly laying stress on various details of importance. He states, however, that he has "abandoned the use of clamps and relies upon suitably formed mosquito forceps" to prevent hæmorrhage. He says nothing about using sponge pressure to check the free oozing which occurs in these operations and which cannot, in our opinion, be satisfactorily stopped by forceps alone. We are not surprised therefore to find that "hæmorrhage may be alarming, and imperil the life of the patient". We doubt whether the "aromatic spirits of ammonia" which should be always at hand to resuscitate the patient, or adrenalin chloride "for the suppression of capillary hæmorrhage" (p. 17), which the author recommends, are as valuable as lip clamps at the corners of the mouth, and sponge pressure, the use of which the author either condemns or does not mention. Herein may lie the explanation of what we can only call the high mortality, in Dr Brophy's hands, of this usually simple operation, as shown by the table on p. 65. By this table we find that his total mortality up to the end of 1921—the latest year for which any figures are given—is 22, 13, and 8 per cent, respectively for infants aged one, two, and three months*. For older children, and for adults up to 30 years and over, the mortality is shown to be much smaller. We are also glad to see that the figures for the years 1915 to 1921 are better than those for the previous years, the mortality for the first two months of life being only 17 and 7 per cent. The total mortality for the next three months works out at 4, 4, and 3 per cent respectively.

Dr Brophy also tells us that his mortality after hare lip operations is greater than that after palate operations, but gives the astonishing explanation (p. 66) "that the lip operation is made when the child is older and more susceptible to depression".

The author gives a good description of the methods commonly employed for correcting the deformity of the nose usually associated with hare lip. For the suture of the cleft lip he employs only horsehair, and uses a strong temporary silk suture to hold the parts together during the suturing of the cleft. He relieves tension on the coaptation sutures by means of the Logan traction bow, which he illustrates (Figs. 58 and 59) and which seems to be a useful device for the cases which need it.

The various steps of the operations are illustrated by a series of drawings, some of which (e.g., Figs. 62–71) are a little fanciful, as they so often are in text-books on this subject. The illustrations do not afford as much help to the surgeon about to operate on one of the more difficult cases so often met with in actual practice as they would have done had they been taken from photographs or accurate drawings of really difficult cases.

The most interesting part of the book is Chapter 2, occupying nearly 200 pages and dealing with cleft palate. He proceeds to develop his views on the anatomy of cleft palate, and states that "the bones are not, as a rule, defective in structure nor incomplete in development. There is only abnormal elevation of the palate and failure of union". With most of this statement we are in agreement. It is accepted by most surgeons, we think, that the two halves of the palate are present but that they have failed to coalesce normally. They remain separated. The

* At one month, 146 operations, 33 deaths. At two months, 198 operations, 26 deaths.
At three months, 231 operations, 19 deaths.

statement that there is an "abnormal elevation of the palate" at least at birth, we believe to be wholly incorrect, and we do not think that Dr Brophy's assertions and illustrations in any way prove this point. Most of us who are familiar with cleft palates and have had opportunities of watching them for a year or two after birth know that at birth, when the cleft is relatively much wider than it is later, the palatine plates are nearly horizontal. It is only later, as the cleft narrows spontaneously and the alveolar ridges develop, that the palatine arch becomes higher. This heightening of the arch and relative narrowing of the cleft is well shown in Fig 159 from one of the author's own patients, a boy with tripartite cleft palate upon whom he performed the first operation at the age of four years. Advantage is taken of these facts by those who advocate the performance of operation on the hard palate—as most surgeons in this country do—at a later period than does Brophy ("within three months after birth", p 126).

The author's advocacy of a wiring operation in early infancy to bring together the separated bones is theoretically good. But what British surgeons (and we think many American also) wish to know is, whether this operation is worth doing—whether the advantage of bringing the edges of the cleft somewhat nearer together (for in most cases they cannot be brought into actual apposition) outweighs the undoubted severity and danger of the operation. Dr Brophy wholly fails to convince us that it does.

Dr Brophy assures us (p 256) that his mortality after cleft-palate operations 'has been extremely low'. The greater number of patients who have died have 'succumbed to gastro-enteritis'. The operation has apparently not had anything to do with the death. It is possible that the operation may have been a contributing factor in some. Apparently it does not occur to him that the retention for several weeks within the mouth and jaws of an infant, of thick lead plates and stout silver wires, may lead to oral sepsis, and that this may be the cause of the gastro-enteritis of which his patients die.

Referring to cleft palate operation, Dr Brophy boldly states in the footnote on p 126 'I am glad to state that the objections which were formerly made to operating on young infants no longer prevail, and that our more progressive surgeons advocate and practise early operations'. If by "early" operations Dr Brophy means operations within the period recommended by him, namely, within three months of birth, it is a great pity that these "progressive surgeons" do not come forward and publish series of consecutive cases, stating exactly the age of each patient, the nature of the cleft and the actual result obtained as regards the condition of the palate when first seen, and, if possible, the subsequent speech of the patient.

Finally, there is an excellent bibliography of 19 pages. This affords well-merited testimony to Dr Brophy's untiring energy and enthusiasm for his views. We find that he has published no fewer than 26 communications on the subject, rather more than half of them to dental congresses, journals, or societies. There are both Subject and Author indexes.

The book is well got up and profusely illustrated, many of the illustrations being good. It will doubtless impress those who have no practical experience of the subjects with which it deals, and for whom, we presume, the book is primarily intended. The surgeon already experienced in this branch of surgery will read the book with interest and perhaps with some amusement, for it is picturesquely written. Here and there he will doubtless pick up some point which will be useful to him in his practice, but we do not think that he will follow implicitly all the advice he finds therein.

A Text Book of Minor Surgery By EDWARD MILTON FOOTR, M.D. New York. Large 8vo. Fifth edition. Pp 815, with over 180 illustrations. 1923. New York and London: D. Appleton & Co. 35s. net.

The fact that this work has reached its fifth edition proves that it supplies a want, but a comparison with the last edition which appeared in 1919 leaves a feeling of disappointment that the book has not been brought more thoroughly up to date. It is true that some additions have been made amounting in all to fourteen

pages, but the bulk of the volume, except for some rearrangement, remains almost unchanged, and the intention of the author expressed in the preface "that all its chapters may be in harmony with the new ideas" can hardly be regarded as accomplished. Many subjects which cannot reasonably be regarded as belonging to the domain of minor surgery are included, and by a judicious removal of these much space might be saved without impairing the practical use of the book.

Among the subjects which first find a place in this edition are the Carrel-Dakin treatment of wounds and the paraffin treatment of burns. A full description is also given of the treatment of varicose veins by the injection of a solution containing carbolic acid and other ingredients. The author seems satisfied with the results, but it is probable that most surgeons will hesitate to adopt such a method, especially when told that it is not necessary for the patient to go to bed and that the injection may be made in the doctor's office. Surely disaster would follow the wide adoption of such a proceeding.

In a work on minor surgery the reader naturally looks for accurate and detailed descriptions of the methods recommended, and reference must be made to various subjects which, together with others, the author might well consider when undertaking another revision. In speaking of retropharyngeal abscess it is stated that the abscess may be opened in the neck *in front of* the sternomastoid. No mention appears to be made of the bronchoscope in the removal of foreign bodies from the air-passages. In the treatment of a malignant tumour of the testicle (which incidentally is hardly a minor surgical procedure) it is advised to remove the organ together with the cord and *inguinal glands*. In the operation for hydrocele the sac is opened, and after removing part of the tunica the edges are sutured to the skin of the scrotal incision, the cavity is loosely packed with gauze and allowed to heal by granulation. Does the author really adopt this method? Does he actually allow a patient to walk home after an operation for varicocele? And does he really operate on an infant with a simple hare-lip without an anæsthetic?

No mention can be found of ischæmic contraction in fractures of the upper limb, or of the risk of tetanus in accidental wounds. Although reference is made to other agents, cocaine is very constantly recommended as a local anæsthetic, and it may be doubted whether this drug should even be mentioned in discussing spinal anæsthesia. Such blemishes, and there are many others, are the more striking because of the general standard of the work, and they should be corrected in the preparation of the next edition.

Two Lectures on Gastric and Duodenal Ulcer. A Record of Ten Years Experience
By SIR BERKELEY MOYNIHAN. Royal 8vo. Pp. 48, illustrated. 1923. Bristol: John Wight & Sons Ltd. 2s. 6d. net.

ALTHOUGH previously published in medical journals, these lectures are so valuable that it is a pleasure to see them in more permanent form. There is a charm about the addresses of Sir Berkeley Moynihan which makes listening to them a pleasure. This charm remains in the written sentences, and in addition they are a lucid statement of the faith and experience of perhaps the greatest authority on these particular subjects, and as such will become classical.

Handbook of Anæsthetics. By J. STUART ROSS, M.B., Ch.B., F.R.C.S.E., Lecturer in Practical Anæsthetics, University of Edinburgh, Hon. Anæsthetist, Edinburgh Dental School. Second Edition. Crown 8vo. Pp. 328 + vii, with 71 illustrations. Edinburgh: E. & S. Livingstone. 8s. net.

IN producing a second edition of this valuable little book, the author has succeeded in keeping its size well within the scope of every student, although he has added enough new material to bring it quite abreast of the times. The work still maintains, as its outstanding feature, a thoroughly practical clinical tone, with just sufficient academic material to explain the author's attitude in reference to certain controversial problems. Among the additions contained in this edition readers will welcome the references to Haldane's work on respiration. The sections dealing with the open method of administering ether and the details of nitrous oxide anæsthesia are

especially valuable. In the former stress is laid upon the importance of keeping the concentration of ether vapour within definite limits in order to obviate the risk of pulmonary complications, and the view is expressed that it is wiser to amplify the strength of the anæsthetic by the addition of small quantities of chloroform than by increasing the dose of ether. Under nitrous oxide there is an unusually clear account of the phenomena peculiar to the induction and development of anæsthesia, and the whole section is very practical as one might expect considering the large amount of pioneer work done by the author in this connection.

There is a clerical error which we feel bound to draw attention to on page 288 where the dose of tropicaine for spinal anæsthesia is given as 0.7 instead of 0.7 gram. Students of anæsthesia will find this book full of reliable information put concisely but not too dogmatically.

Saint Bartholomew's Hospital Reports Vol. LV Edited by I. W. Andrews, W. McAdam Eccles, G. L. Gask, W. D. Harmer, H. Thurshield, and H. Williams. 4to. Pp. 180. 1922. London: John Murray. 10s. 6d.

The reviewer's appreciation of this number is in a sense painful, in that it contains a memorial notice of the late Dr. Bimbridge, F.R.S., whose work he was privileged to see many years ago when Dr. Bimbridge was doing research work at University College. His breadth of mental outlook and his highly developed critical sense fitted him so unusually for research as to make his loss the greater. It was also peculiarly interesting to read in the Reports of another hospital the life of the greatest of Guy's surgeons, Sir Astley Cooper. Mr. Geoffrey Keynes has carefully gone through the records at his disposal, and in sketching a very readable biography gives an interesting and clear-cut account of the causes of Sir Astley Cooper's success, and indicates the qualities of mind and character which made his rise to the head of the profession so phenomenally rapid. The volume also contains a fifth series of ninety-five cases of intussusception carefully analysed and brought up to date by Mr. W. E. Wilson. Not the least interesting features of this number are the "Descriptions of Specimens added to the Museum during the year 1921", which are models not only for the uniform manner in which each specimen is described, but also for the aptness of the terms used and the conciseness of the diction.

Saint Bartholomew's Hospital Reports Vol. LVI, Part 2. 4to. Pp. 198. 1923. London: John Murray.

Much of this volume is devoted to the various aspects of syphilis. So old and conservative an institution is to be congratulated in that it invites authorities such as Mr. J. Adams to lecture within its walls. His paper on "Antenatal Syphilis" well summarizes all that is known of the subject at the present time. Of the other articles that on "Diverticula of the Bladder" by Mr. W. Girling Ball discusses very thoroughly the different theories which have been put forward to account for these lesions, and is well illustrated by some unusually well-executed drawings of specimens.

Essentials of Oral Surgery By VIRGIN PAPIN BEAN, A.M., M.D., F.A.C.S., Professor of Oral Surgery in the Washington University Dental School, and ROBERT HENRY IVY, M.D., D.D.S., F.A.C.S., Professor of Maxillo-facial Surgery in the Graduate School of Medicine. Royal 8vo. Pp. 526, with 335 illustrations. 1923. London: Henry Kimpton. 32s. net.

This is a text-book containing the subject matter taught to their undergraduate students by the authors, who explain that they have laid stress on the recognition of surgical conditions, but have not thought it necessary to describe major operations in detail.

Keeping in mind the chief object of the book, and passing the main chapters in review, one notes instruction in Chapter I which should be useful to higher dental students, and the consideration of points of anatomical survey as applied to practical work is well conducted. Both the chapters on inflammation and on special infections

contain sound surgical teaching. The classification of tumours is useful, and also the chapter on hæmorrhage and shock, except that the injection of serum should not be advocated without warning students of the possibility of anaphylaxis.

Dealing with the treatment of X-ray burns the authors say "The best form of treatment for severe burns seems to be the removal of necrotic tissue and granulations, and the application of thick grafts or flaps transferred from neighbouring healthy tissue. According to F. C. Wood, even if such flap grafts slough, they sometimes leave the tissue in such a healthy condition that Thiersch grafts will then grow satisfactorily." Though it is perfectly correct to advocate grafting, some stress might have been laid on the fact that the excision is the more important part of the operation, as, after it, even without subsequent grafting, the pain and general character of the burn will change, and it will heal better than if it had been left alone.

The chapter on fractures contains some illuminating discussion, particularly on fractures of the jaw—obviously a subject on which the authors have thought a great deal—and on the whole the methods advocated for splinting the fracture are to be recommended.

The treatment advised for peri-apical affections is not generally accepted in this country. It does not appear necessary in a book of this sort to deal with the extraction of teeth, but more should have been said on the common condition of the impacted third molar. In diseases of the maxillary sinus, the authors touch on too many subjects, giving a little knowledge which would prove dangerous to the student. This is particularly the case in the diagnosis, which would not pass muster in the clinic of a throat and nose surgeon, though the advice for treatment is good. Tumours of mouth and jaws are well dealt with, and the description of the congenital clefts is very good. The operative treatment is more difficult to criticize, because it is, to a certain extent, condensed and, in fact, is afforded rather meagre space for such a large subject, but it appears a fairly sound epitome of the usually adopted principles. For orthodontia, the authors' operation is given—a sound though severe treatment. There are some valuable pages on diseases of the mandibular joints and resection of the condyle, and on the affections of the tongue.

In the last chapter the use of local anæsthesia is well worked out, but the methods of general anæsthesia as described here are far inferior to those practised in this country, very little is made of the intratracheal method, and it is stated that considerable practice in the introducing of the tube is required, which is, of course, incorrect.

On the whole, then, the book contains sound instruction from two good surgical teachers, and is also interesting as a record of personal practice. As a book of reference it will very often supply what is wanted, but it will also often disappoint because of lack of detail. There is a certain amount of padding—preparation of the operation fields and so on—with explanations in detail of things the student should know before he ever reads a book. Some of the radiograms are very bad—the one on page 153 for instance, which shows nothing at all, and has to be explained by means of arrows.

Lateral Curvature of the Spine, and Round Shoulders. By ROBERT W. LOVETT, M.D., Sc.D., Professor of Orthopædic Surgery, Harvard University. Fourth edition, revised. Pp. 218 + vii, with 172 illustrations. 1923. London: H. K. Lewis & Co. Ltd. 12s. 6d. net.

DR LOVETT'S book remains the most comprehensive account of scoliosis at present published in England or America. It is, however, in some points still incomplete, and the new edition cannot be considered as quite up to date. The most striking omission is the absence of any account of the bearing of recent muscle physiology upon the development of scoliosis and kyphosis, the postural activity of muscles is not mentioned at all. Dr Lovett expresses the view that postural curvatures of the spine are not likely to be cured spontaneously, but only as the result of suitable remedial gymnastics. In this he takes a view which it is difficult to support if observations made in schools are borne in mind, for we find that 25 per cent of school children show a postural curvature, and this percentage steadily diminishes as adult

life is reached without any treatment whatever. In fact Dr Lovett seems to ascribe too little to the normal development of a sense of balance in the cure of scoliosis.

In the very excellent short set of exercises too much insistence is made upon the necessity for fixing the pelvis as a preliminary to many of the movements. Here again there is a failure to realize the importance of developing a sense of balance, the artificial fixing of the pelvis assisting this sense so greatly as to interfere with the educational value of the exercises.

Dr Lovett rightly insists upon the difference between postural and structural curvatures or as he calls them false and true scoliosis, stating that the latter is a bone problem. An excellent account is given of the various methods of forcible correction and the use of plaster-of-Paris jackets. Abbott's method is briefly described and the findings of the Committee of the American Orthopaedic Association upon the value of this method are given. The investigations of this committee have relegated this method to its proper position in treatment, i.e. as a method which has its uses but which is not the infallible cure that it was claimed to be by its author. There is a complete omission of all descriptions of the uses of recumbent splints, such as plaster-of-Paris beds and of correction by pressure in them. In spite of these various omissions the book remains an invaluable one for the orthopaedic surgeon and medical gymnast and should be studied by all members of these two professions who are concerned in the treatment of spinal curvatures.

Radiography and Radiotherapeutics. By ROBERT KNOX, M.D., C.M., M.B.C.S. 1 R.C.P., Consulting Radiologist, Great Northern Central Hospital, London. Part I. Radiography. Fourth edition. Super royal 8vo. Pp. 118. xxy, with 93 plates and 137 illustrations. 1923. London: A & C Black Ltd. 10s. net.

THE fourth edition of Dr Knox's well-known book on radiography has been brought up to date and considerably enlarged, especially as regards the chapters dealing with the examination of the gall-bladder and urinary tract. This edition undoubtedly maintains the high reputation already acquired by the work, which remains the most comprehensive and authoritative treatise on the subject in this country.

The general arrangement of the book is excellent and a large amount of detail is included in a comparatively small compass. The essentials of the physics of the subject are fully dealt with, and the student and general practitioner alike will find no difficulty in gaining a clear understanding from these chapters of the production and use of X rays for diagnostic purposes. The various types of apparatus employed in radiography are carefully described, and many points of practical value are emphasized. The chapters on diagnosis are copiously illustrated, and most of the plates are excellent, especially those dealing with the chest and gastro-intestinal tract.

The appendix contains several chapters giving useful hints on the differential diagnosis of renal and gall-bladder cases, also a description of the Lihensfeld tube and a chapter on the Potter-Bucky diaphragm, the use of which is now regarded as indispensable by most radiographers.

Dr Knox is to be congratulated on the continued success of his book, the present edition of which bids fair to maintain its popularity.

A Handbook of Surgery. By GEORGE L. CHINN, M.B., C.M., F.R.C.S. Ed., Surgeon, Edinburgh Royal Infirmary, Senior Lecturer and Examiner in Clinical Surgery, University of Edinburgh. Crown 8vo. Pp. 592 + xii, with 109 illustrations. 1923. Edinburgh: E & S Livingstone. 12s. 6d. net.

THIS small text-book was written with the object of providing a book for those who have not time to study larger volumes. An attempt is made to emphasize the more common and more important surgical conditions, and little space is given to the consideration of surgical rarities. It presumably represents the commonly accepted teaching in the Edinburgh school. The writing is clear and lucid, and a very great deal of information is compressed into a small compass. The illustrations, although numerous, are not perhaps as clear and diagrammatic as they might have been for a work of this kind.

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